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FINAL HUMAN FACTORS REPORT FOR THE SQS-26 SONAR SYNTHESIS STUDY--ETC(U)

OCT 67 B W YAEGER, L P SCHRENK N61339-67-C-0022

UNCLASSIFIED 422-67-WC NL

1 OF 3

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CO-6835

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FINAL HUMAN FACTORS REPORT

FOR THE SQS-26 SONAR

SYNTHESIS STUDY (U)

by

B. W. Yaeger

L. P. Schrenk

Honeywell, Inc.
1200 East San Bernardino Road
West Covina, California 91790

Contract No. 61339-67-C-0022
Item A006AB

October 1967

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see 1473

NAVAL TRAINING DEVICE CENTER

ORLANDO, FLORIDA

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ABSTRACT

An investigation was made of the human factors requirements associated with the development program to add a simulated SQS-26BX Sonar System to the Surface Ship ASW Attack Trainer, Device 14A2A. Parameters important to the problem of training SQS-26BX Sonar teams were established through a Task Analysis, Training Analysis, and Functional Analysis of SQS-26BX Sonar operator tasks. Recommendations are made for levels of training required, simulation capabilities, displays and controls needed, performance evaluation system, design of an instructors control station, and the levels of realism to be incorporated in an SQS-26BX/14A2A combined team training facility.

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Consoles						
Training						
SQS-26BX Sonar						
Sonar						
Simulation						
Convergence Zone (Sound)						
Bottom Bounce (Sonar)						
Surface Duct (Sonar)						

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FINAL HUMAN FACTORS REPORT for the SQS-26 SONAR SYNTHESIS STUDY (U)

Device 14A2A

B. W. YAEGER
L. P. SCHRENK

HONEYWELL INC.
1200 East San Bernardino Road
West Covina, California 91790

Contract No. N61339-67-C-0022
Item A006AA

October 1967

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including front matter.

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Contract No. N61339-67-C-0022

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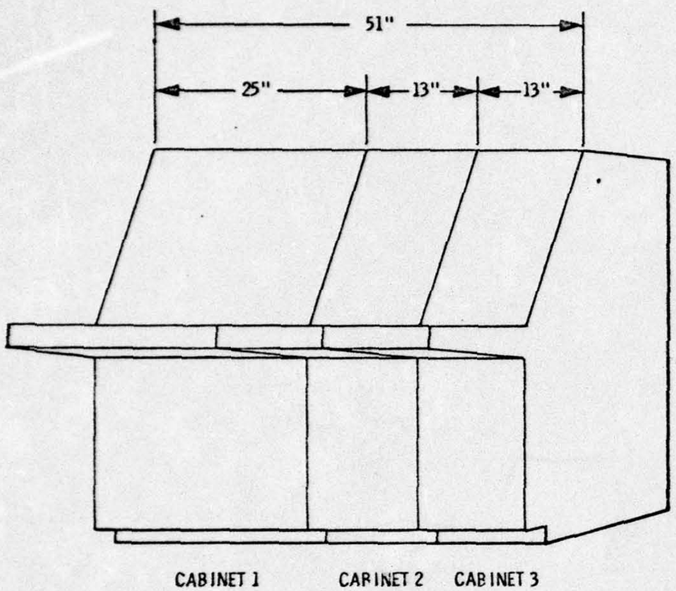
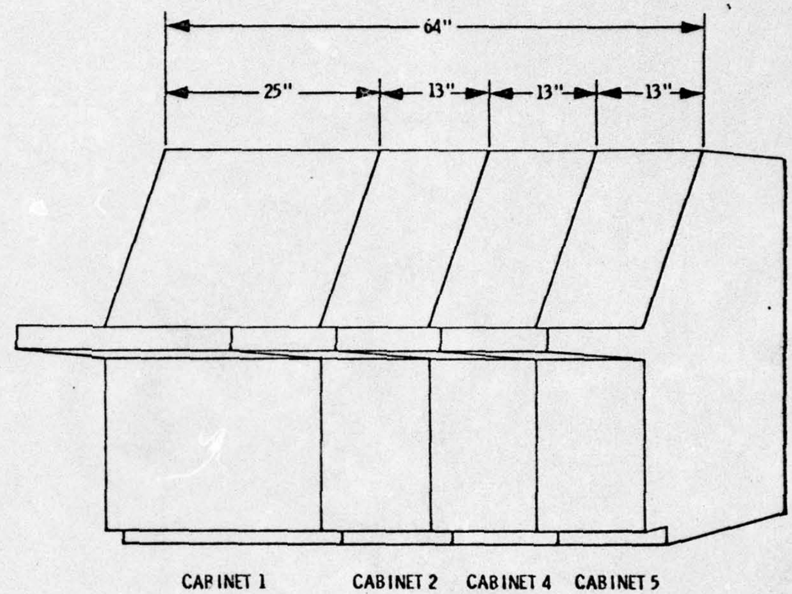


JOINT MODE STATION



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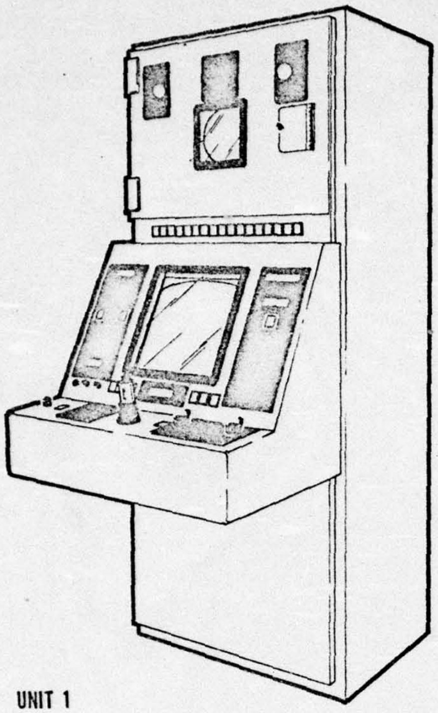
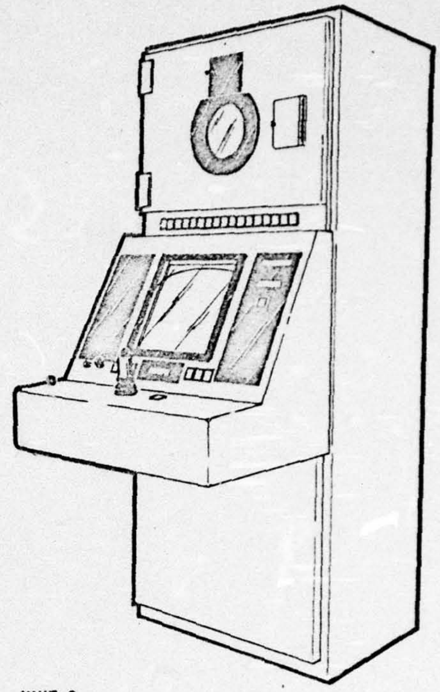


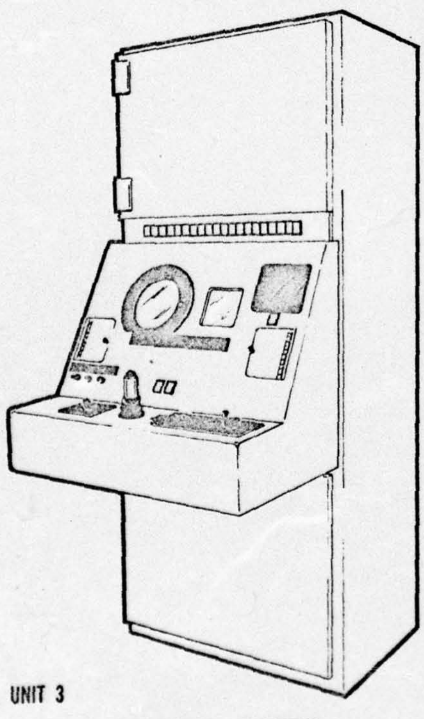
UNIT 1

A-SCAN CONSOLE



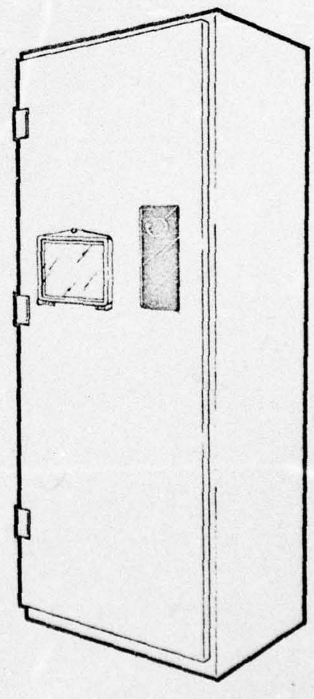
UNIT 2

B-SCAN CONSOLE



UNIT 3

TRACKING CONSOLE



UNIT 4

DIMUS CABINET

Performance Evaluation

- Procedures
- Communication
- Performance Data
  - Time
  - Accuracy
  - Scores (averages)
- Standards
  - Performance on Standard Problems
  - Fleet standards for comparison

Recommended Solution - Level 5

Complete SQS-26 Simulation - Independent/Joint Capability

- Provide 5 Operator Consoles

  A-Scan Console
  B-Scan Console
  SSI Console
  DIMUS
  Test Set

- Provide realistic Video for both channels

  Targets and Surface Ships
  Noise and Reverberation
  Wakes

- Provide 2 Instructor Consoles

  1. For use with 14A2A Instructor Console
  2. For use in independent mode

- Provide for Performance Evaluation

Possible Solutions

Level			
Level	1	Instructor Input to ASW	3%
	2	Tracking Console Simulation only	16%
	3	Surface Duct Simulation only	33%
	4	Complete SQS-26 Simulation for 14A2A	100%
	5	Complete SQS-26 Simulation - Independent/Joint Capability	103%
	6	SQS-26 Simulation and Increase 14A2A Capability (SAU Commander)	106%
	7	SQS-26 Simulation and Two-Ship Capability (Bridge & CIC & Sonar)	116%
	8	SQS-26 Simulation and Additional 14A2	183%
	9	SAU Team Training Facility	300+%

Summary of Training Requirements

- Operator Training is essential.
- Sonar Team Training is necessary.
- Both Surface Duct & Depressed Channels are required.
- Coordination with UB Plot, CIC & Bridge is required.
- Coordination with other ASW Units is desirable.

Need for training/Shore based trainer

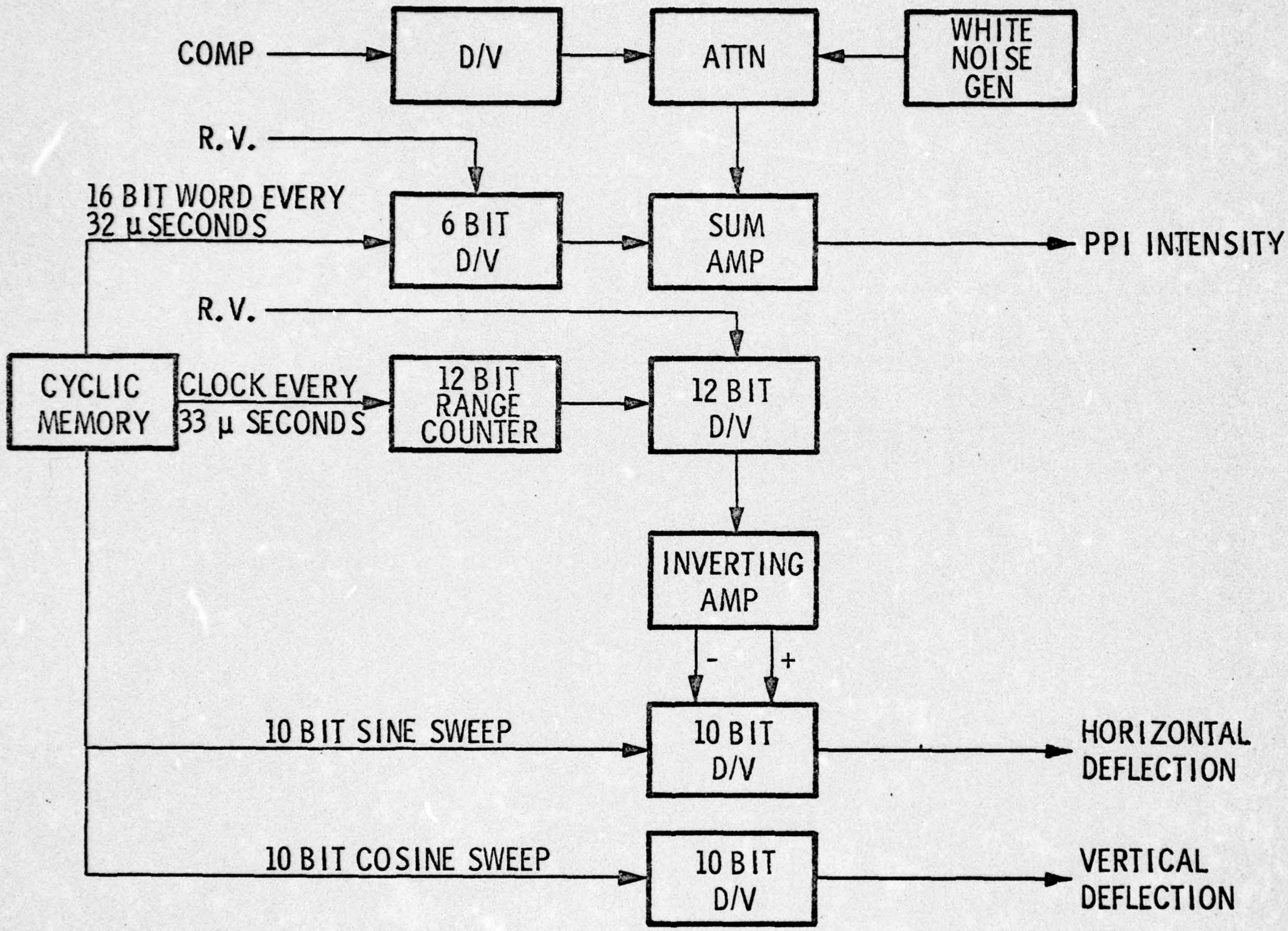
- System Analysis
- Mission Analysis
- Operator Task Analysis (1218-4)
- Analyze Training Requirements (1218-4)
- Determine Trainer Requirements

SQS-26(BX) Sonar System

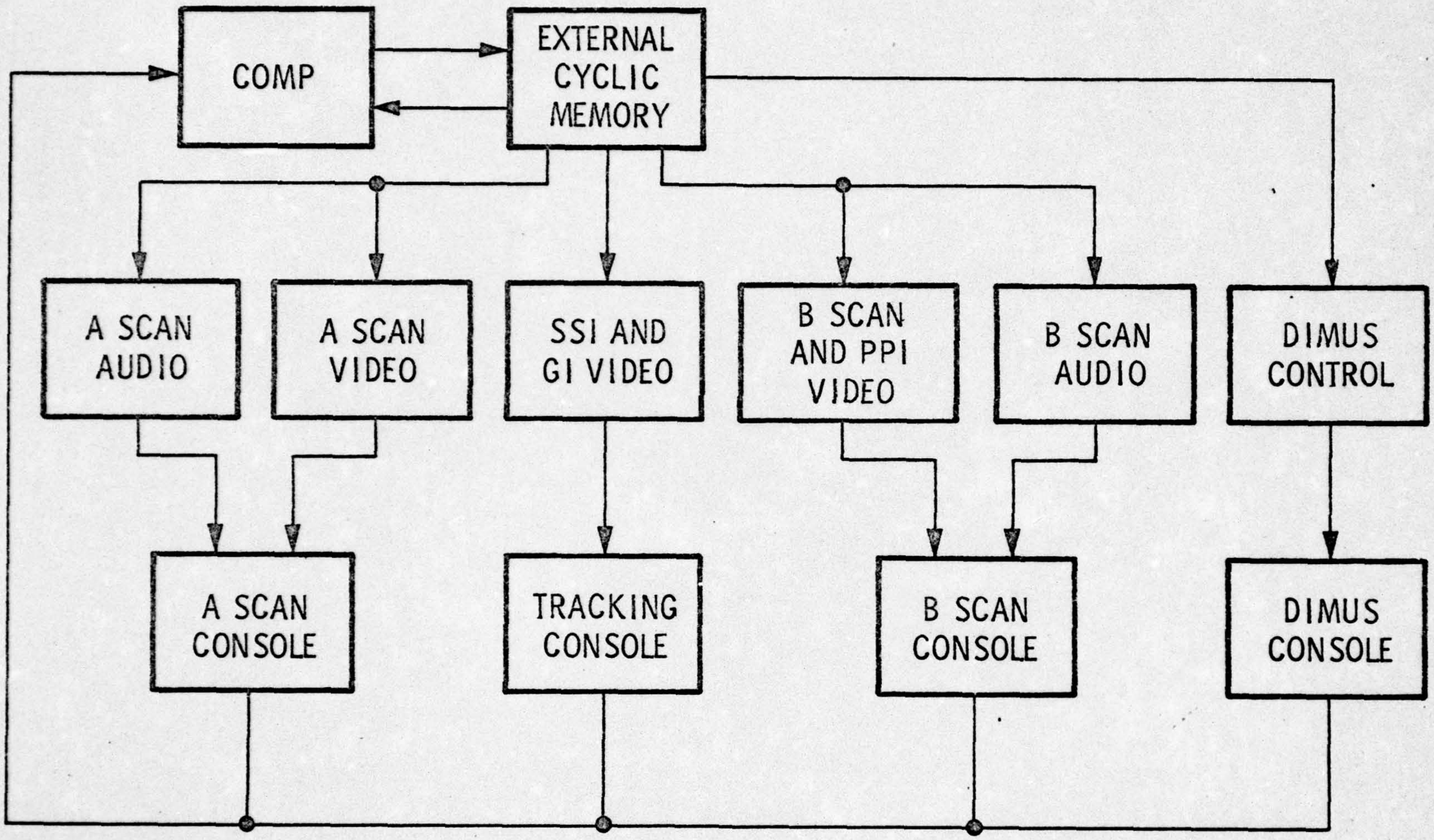
Human Factors Analysis

For Training Requirements

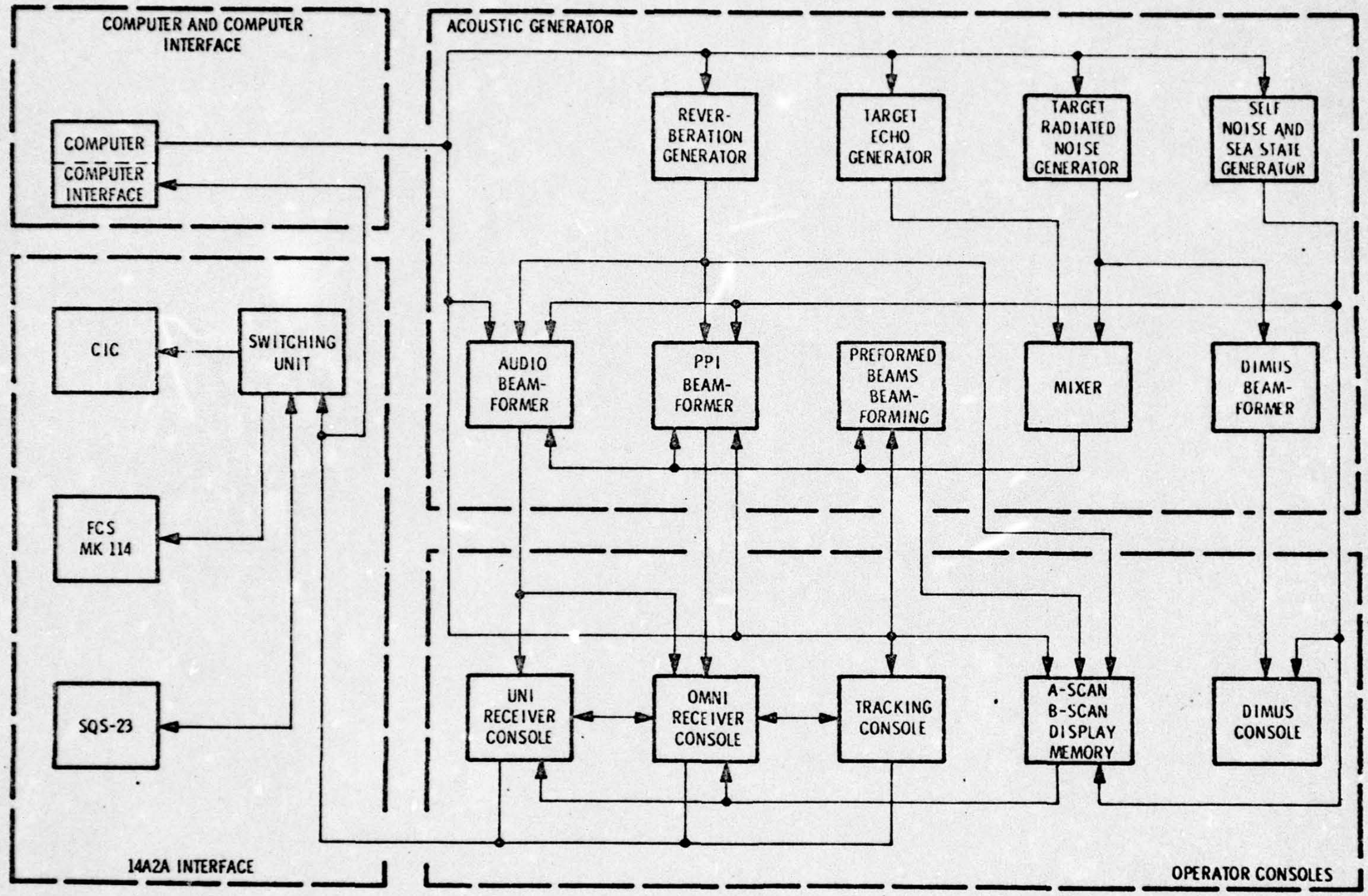
Related to Shore based Training



PPI DISPLAY CONVERTER SUBSYSTEM



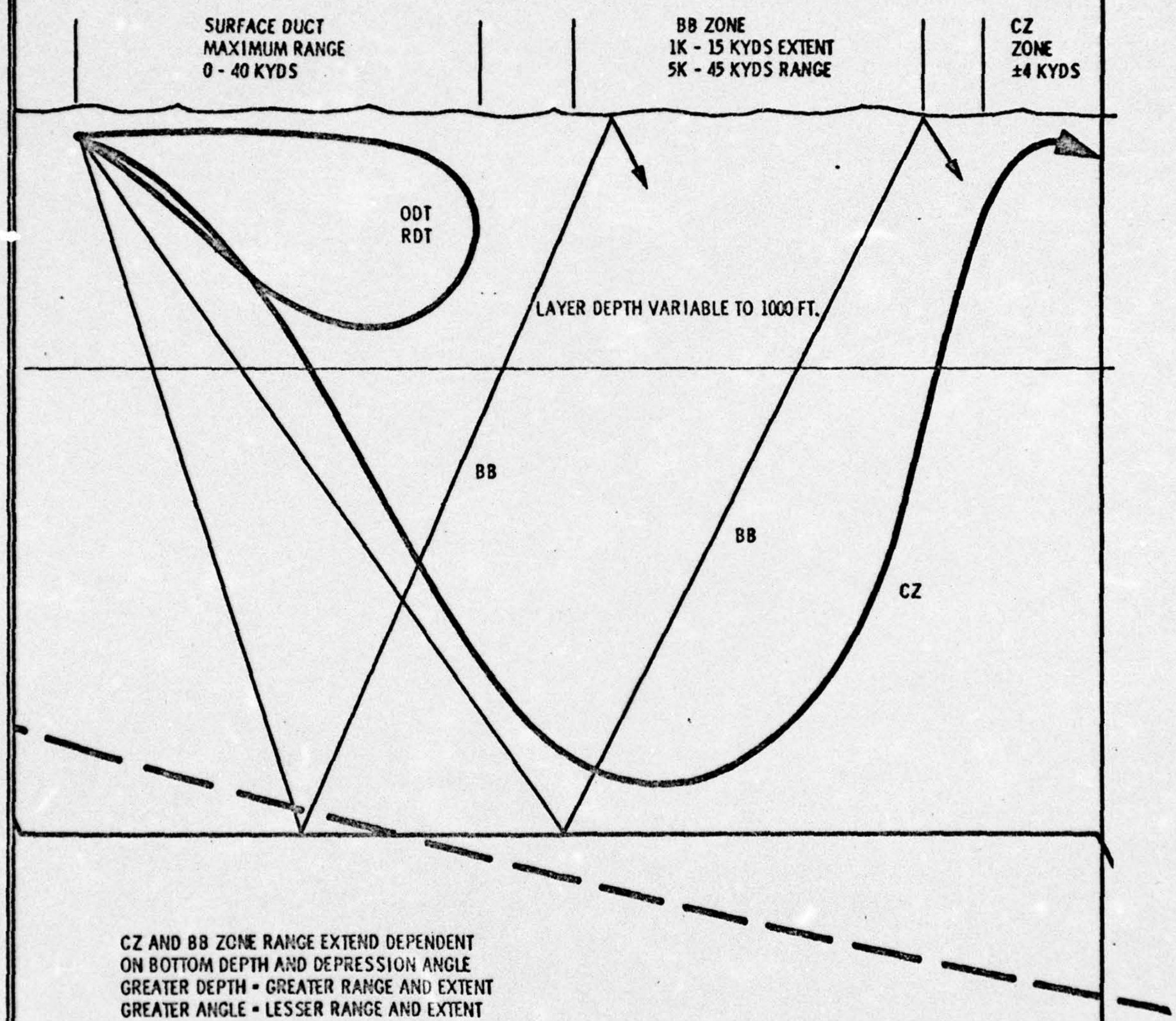
FUNCTIONAL SYSTEM BLOCK DIAGRAM



COMPUTER AND COMPUTER INTERFACE
COMPUTER
COMPUTER INTERFACE
ACOUSTIC GENERATOR
REVER-BERATION GENERATOR
TARGET ECHO GENERATOR
TARGET RADIATED NOISE GENERATOR
SELF NOISE AND SEA STATE GENERATOR
CIC
SWITCHING UNIT
AUDIO BEAM-FORMER
PPI BEAM-FORMER
PREFORMED BEAMS BEAM-FORMING
MIXER
DIMUS BEAM-FORMER
FCS MK 114
SQS-23
UNI RECEIVER CONSOLE
OMNI RECEIVER CONSOLE
TRACKING CONSOLE
A-SCAN B-SCAN DISPLAY MEMORY
DIMUS CONSOLE
14A2A INTERFACE
OPERATOR CONSOLES

DEEP WATER

OCEAN BOTTOM CONDITIONS
APPROXIMATELY 1000 FATHOMS TO 2500 FATHOMS
BB/ODT, CZ(ODT) ODT OR RDT ONLY



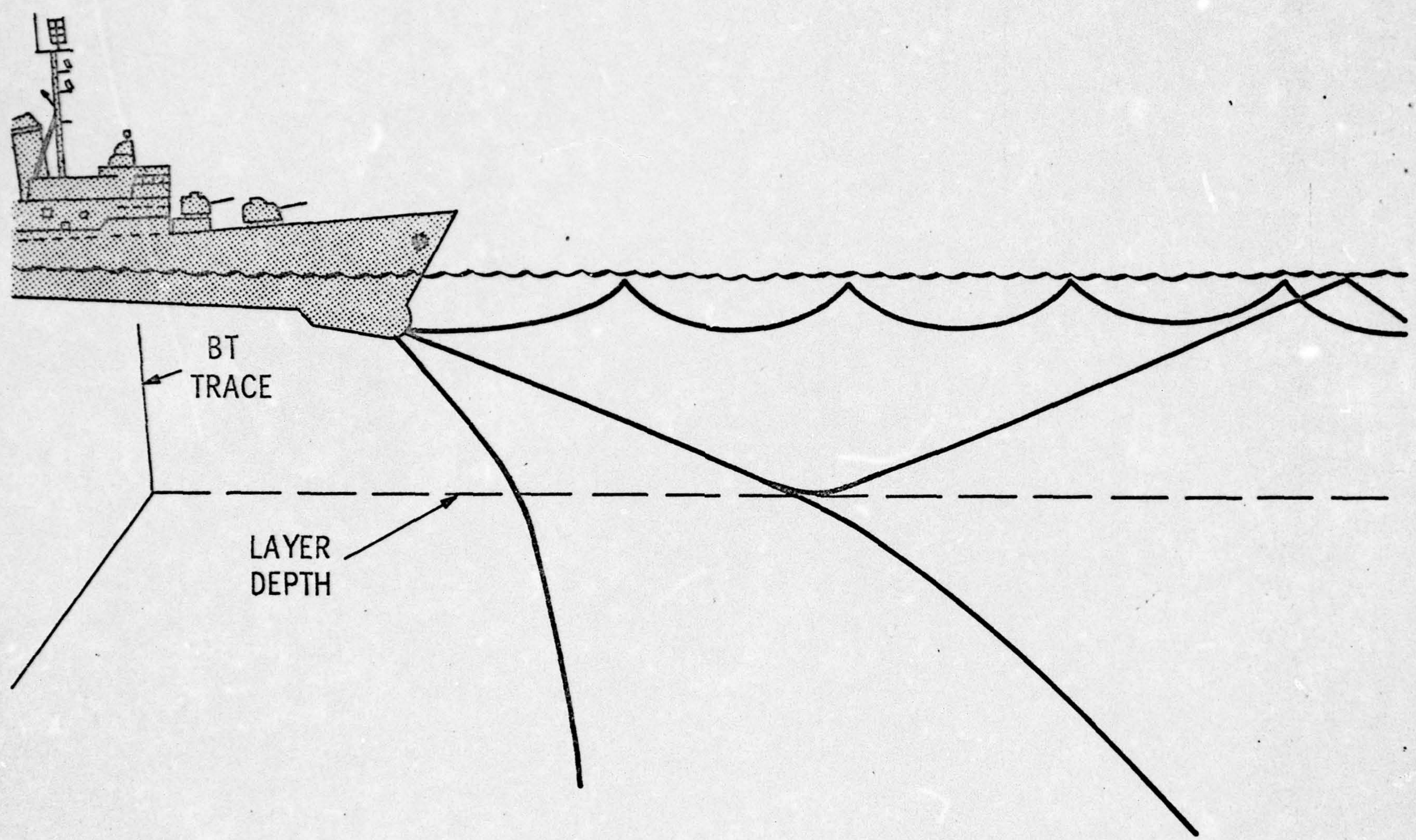
CZ AND BB ZONE RANGE EXTEND DEPENDENT
ON BOTTOM DEPTH AND DEPRESSION ANGLE
GREATER DEPTH = GREATER RANGE AND EXTENT
GREATER ANGLE = LESSER RANGE AND EXTENT

2500 FATHOM
15,000 FT.

RANGE FOR BB AND CZ AFFECTED BY
- WAVE HEIGHT AND WIND
- OWN SPEED
- REVERBERATION CONDITIONS

BB UNDER SOME CONDITIONS
(WHEN DEPTH NOT EXCESSIVE)

SURFACE DUCT RANGE DEPENDENT ON
- LAYER DEPTH
- WAVE HEIGHT
- OWN SPEED


BT
TRACE
LAYER
DEPTH

CONTRACT SCHEDULE

	S	O	N	D	J	F
HUMAN FACTORS REPORT		▲				
MATH MODEL REPORT				▲		
SYSTEM SIMULATION REPORT				▲		
INSTRUCTOR'S STATION REPORT					▲	
PROGRAMING REPORT					▲	
INPUT/OUTPUT REPORT					▲	
FINAL ENGINEERING DATA						▲

AN/SQS-26(BX)

Sonar Synthesis Study

Contract N61339-67-C-0022

Financial Status

as of

27 August 1967

Target Cost, Total	$190,021
Cost to Date	114,262
Remaining Target Funding	$ 75,759

AN/SQS-26(BX)
Sonar Synthesis Study

find out dates.

PHILLIPS NTDC

Study Requirements

- Add SQS-26(BX) Sonar team training to 14A2A.
  (now going CX only not BX) Honeywell's BLDG THIS.
- Provide the capability to train sonar teams in the search, detection, classification, track and attack phases of the ASW problem.
- Implement the trainer using simulation techniques (no GFE) that provide full fidelity of the student stations.
- Produce engineering reports on:
  - Math Model
  - SystemSimulation
  - Programing
  - Instructors Station
  - Human Factors
  - Input/Output

ENCLOSURE (7)

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SECTION I

GENERAL INFORMATION

INTRODUCTION

(U) The purpose of this study is to define the requirements for SQS-26BX Sonar team trainers based on a systematic Human Factors analysis. Specifically, the study was directed to establish the need for adding an AN/SQS-26BX Sonar training capability to the existing Surface Ship ASW Attack Trainer, Device 14A2A, and to identify the parameters required to provide effective training. The SQS-26BX Sonar System is representative of the new, long-range, complex Sonar Systems currently being installed on new-construction ASW ships. Device 14A2A is the Navy's newest and most realistic ASW team trainer.

(U) The need for adding the AN/SQS-26BX Sonar capability to existing ASW team trainers is based on the fact that crews on ships equipped with longer range and more complex sonars require team training at least as urgently as do crews on ships with short range Sonar Systems. The human factors portion of the overall AN/SQS-26BX Sonar synthesis study was directed to evaluate the team training requirements of SQS-26 Sonar operators by performing a task analysis of operator positions in the system. Secondly, the study was directed to determine and recommend the level and kind of equipment simulation that should be added to Surface Ship ASW Attack Trainer, Device 14A2A, to support sonar operator training needs. Three general levels of equipment simulation considered were: (1) a minimum capability that will provide processed AN/SQS-26 Sonar information to the fire control system of Device 14A2A; (2) sufficent simulation to permit comprehensive procedural training for the SQS-26 Sonar team as well as the other ASW team members; and (3) complete simulation of the SQS-26 Sonar System, including full detection and classification capabilities. As envisioned above, the first level would require little or no simulation of operation equipment. The second level would require simulation of the equipment but not the signal characteristics of the operational environment. The third level would entail realistic simualtion of the entire AN/SQS-26 Sonar System, including all operator consoles and associated displays and a realistic simulation of the ocean environment.

(U) In this study, the task analysis of the three operators and sonar supervisor composing the SQS-26 Sonar team was used as the primary basis for deriving training requirements. Through the analysis of tasks performed by the operators, and their interactions with one another and the remainder of the tactical ASW team, the difficulty and criticality of various operator tasks relative to successful team performance were assessed. Additionally, recommendations are made for the realism of operator equipment and display situation, controls, and displays to be used by instructor personnel, and for a performance evaluation system for the recommended AN/SQS-26 Device 14A2A union.

(U) The major phases of the human factors analysis conducted for this study were:

1. Background and System familiarization

2. Task analysis of SQS-26BX Sonar operators

(U) Data and information gathered in these two phases lead to recommendations and conclusions in the following areas:

1. SQS-26BX Sonar System Objectives

2. Criticality and difficulty of SQS-26BX operators tasks

3. Training requirements for SQS-26BX operators

4. Objectives of a SQS-26BX Sonar Trainer

5. Levels of Simulation for a SQS-26BX Trainer

6. Levels of trainer realism

7. Performance evaluations system

8. Instructor display, control and capability requirements

(U) This study was concerned only with the ASW missions of AN/SQS-26 Sonar equipped ships. Other missions were not studied. Further, the present study was directed primarily at the problem of team training. Individual, subteam, and onboard training were considered only as they impinge on the team training problem ashore. Although investigation and definition of a complete training program and utilization guide for the SQS-26/14A2A union is highly desirable, the development of such materials was beyond the scope of the present contract.

THE ASW MISSION

(U) The ASW mission of AN/SQS-26 Sonar equipped ships in the fleet is the detection, classification, and neutralization of hostile submarines. The unique characteristics of the SQS-26 indicate that these ships will be used for long-range detection whenever possible. As well as for detection and neutralization of hostile submarines at close ranges. The detection and attack mission may be made from picket position, convoy or task force screens, as part of a Search and Attack Unit (SAU), or when steaming independently.

(U) When possible, attacks on hostile submarines are made by multiple units which may include several surface ships, aircraft and helicopters. These multiunit attacks are required to reduce the inherent advantages of the submerged submarines. However, each surface ship which is fitted for ASW detection and attack must be ready and qualified to conduct the entire attack alone.

(U) All ASW ships must be ready to proceed with an appropriate action when a target is detected. This action will depend upon the combination of target range at detection, weapons, available, support units available, and the mission of the ship. In each case the appropriate action may follow one of several

available tactical plans developed for given sets of circumstances and missions. The plan selected will depend on whether the primary mission was in a convoy or task force screen, in a SAU, on picket duty, or independent steaming in the open ocean. In the convoy or task force screen, ASW ships and units are assigned to specific positions around the main body. The primary purpose of this screen is to detect and to prevent hostile submarines from penetrating the screen and attacking the screened vessels.

(U) In a SAU mission, a small group of ASW ships, aircraft and/or helicopters are dispatched toward a point where a possible submarine has been located to search a goegraphic area. Generally, attacks against submarines are made by a SAU, which is made up of available ASW elements in the vicinity of the contact. Thus, a variety of combinations of units may be assembled and each combination of units requires special tactics to captialize on the collective capability of the available surface and air elements.

(U) Other ASW missions include barrier patrols, sorties, picket stations, and indpendent steaming searches which may result in long range detection or a short range attack.

(U) In most cases, if a sonar contact is made, the detecting ship attacks immediately or a SAU is formed to proceed with the attack. Usually, the detecting ship conducts the attack alone, it is because the situation is urgent, with the submarine at close range and presenting an immediate threat. However, the detecting ship may also be ordered to close from long range and conduct an attack along because other units are not available.

(U) In a SAU, multiple elements or units are involved and the action of each unit must be coordinated with the action of all other units. This is normally done by the SAU Commander who is usually the senior tactical officer on board one of the surface ships in the SAU.

(U) The SAU Commander selects the tactic to be used, assigns units to preplanned positions, and monitors the action. Depending upon the available elements in the SAU, the tactic selected, and the success of the action, on-the-spot variations in timing, assignments, and tactics may be ordered by the SAU Commander. Similarly, defensive moves by the submarine must be countered with changes in the attack or change in tactics.

(U) Coordination of effort among the units of the SAU is of paramount importance for successful attack. All members of the SAU team must coordinate their action, pass current information back and forth, and function with a cooperative interdependent team effort. For example, sonar and radar operators and others must coordinate their efforts to conduct a successful vectored aircraft attack against a submerged target detected on sonar.

(U) Experience has shown that considerable training and practice in this team effort is necessary to assure that all units of the SAU team work together smoothly in an actual attack.

ASW TACTICAL PROBLEMS

(U) When an underwater target is detected, it is classified as a possible submarine, or nonsubmarine. If it is a possible sub and hostile, it is attacked. With the longer range capability of the SQS-26 Sonar, ships so equipped will probably take a different type of action than would SQS-23 ships detecting a target at close-in ranges. With SQS-23 equipment, the weapon range is frequently greater than the sonar detection range and thus an attack may commence immediately upon detection and classification, this situation will also occur with the SQS-26 System under various ocean conditions, so the ship must be ready to attack immediately. Since the sonar range of the SQS-26 ships may be up to six times greater than the effective range of current weapons, different tactics may be required after long range detection. However, there is no established doctrine on tactics that will be used with the SQS-26. Rather, the presumed tactics to date are based on previous approaches.

(U) As indicated above, ASW ships frequently operate with other ships or aircraft in a coordinated team effort. If other ships or units are available, it is quite unlikely that the ship that first makes a long range detection with SQS-26 Sonar will be the one to close and attack. Rather, an obvious tactic would be for the detecting ship to hold contact and to vector in an aircraft or supporting surface ship to conduct the attack.

(C) A second tactical problem involves the attack capability of the SQS-26 equipped ship. As on current ships, the target must be closed to within range of close in direct-path detection and within range of the ships weapons. In this case, Own Ship could receive orders to close range and would search for the target in the surface duct channel. When the target was detected and classified, Own Ship would continue the problem, determine the target's course and speed, and carry out an attack with the appropriate weapons.

(C) A third tactical situation that is expected to arise on SQS-26 ships is the detection, tracking, and attack of two targets simultaneously. This can occur by detecting one target in the short range, surface duct channel (within range of ASROC), and detecting a second target in the long range channel. The target detected in the surface duct channel could be tracked by sonar and attacked with ASROC while the long-range target could be tracked in CIC and one of the support units vectored in for an attack. This kind of problem will require considerable coordination between units.

(U) These three general types of problem situations, with variations and combinations, are necessary to provide the kind of training required for SQS-26 ships. This study will identify and recommend the equipment necessary to permit these three pertinent types of problem to be run on the Device 14A2A Trainer.

ASW TRAINING

(U) Each man involved in the ASW problem must perform specific duties to enable the team to complete the ASW mission effectively. Each team member must learn to perform his assigned tasks to the required level of skill. Some of this learning can occur independently of the team, on an individual basis.

This is individual training and must be accomplished before the team can function effectively. The remainder of the tasks must be learned in conjunction with other team members in a team-training context. The need for team training is different from, and in addition to, the training necessary to perform individual jobs, since performance of a team is something more than a simple collection of individuals each doing his own task well. Team training and practice on specific team problems is required to obtain well-coordinated and effective team performance.

(U) Training in team coordination should be conducted with each group of men comprising a team or subteam in the ASW attack. Three combinations of men are involved and should be considered for training. These are: (1) the individual specialty teams, such as sonar teams on each ship; (2) all the ASW personnel on one ship (that is, the Own Ship team); and (3) the men involved in coordinating the multiunit actions (that is, the SAU team).

SUBTEAM TRAINING

(U) The first team training level consists of the men in various subteams. The subteams of concern here are: (a) the sonar operators, (b) the men in Combat Information Center (CIC), (c) Underwater Battery Plotting Room (UB Plot), (d) Launcher Captain's Control Station (LCCS), and (e) the Bridge (Conn). At this level, normal operations aboard ship provide much of the basic team training. However, the subteam coordination required in contact and attack procedures with actual submarines cannot often be practiced effectively at sea. While it is possible to provide simulated or taped targets for a training mode of operation, experiences in the fleet, to date has been that this is difficult due to a number of reasons including the lack of realistic and flexible problem generators. As a supplement to at sea exercises, subteam training has been provided successfully in comprehensive shorebased training simulators such as the 14A2A.

OWN SHIP ASW TEAM TRAINING

(U) The second level of team training is the training of all personnel on board one ship to perform as a team in specific phases of a problem. In ASW, this includes the group of sonar operators who detect, track and identify the target, the men on the bridge who conn the ship, the men in CIC who plot the action and recommend moves in the battle, and the fire control and weapons operators who prepare and fire the weapons. These men and their respective officers and the commanding officer make up an Own Ship ASW team. With this many men involved, it is obvious that considerable coordination, communication, and cooperation is required for the successful completion of an ASW attack. At present, sufficient submarine services are not available for frequent at-sea training. The Surface Ship ASW Attack Trainer, Device 14A2A, provides a facility to enable this group of men to learn and practice these functions.

SAU TEAM TRAINING

(U) At the most complex level, the ships team need to learn and practice operations in the context of a SAU group. This can occur in an actual SAU operation at sea, or by simulation in a tactical trainer. In a trainer, personnel from several ships and aircraft could man stations and function as they would

on their own units in a coordinated problem, or personnel from only one ship could be trained with instructors simulating the other ships and aircraft in the SAU. Several types of multiunit training devices are being used in the Navy currently. For training in tactics and team coordination to take advantage of the long-range capability of the SQS-26, it is necessary that the basic training problem include interactions with this other unit or units. Own ship could then detect the target, inform CIC, Bridge, and the SAU Commander, and maneuver to hold contact while vectoring in the other unit. This is presumed to be one of several necessary and vital training requirements.

SHIPBOARD TEAM TRAINING

(U) Crews aboard ships at sea can practice some ASW team activities without actual underwater targets during normal operations. Experience has shown, however, that ASW team training at sea with simulated targets are of limited value . Ship crews have been able to benefit significantly from shorebased team training facilities, such as the Surface Ship ASW Attack Trainer, Device 14A2A.

(U) Similarly multiunit practice with actual submarine targets is infrequent at sea due to the shortage of submarine services and the difficulty of assembling the required units. This limitation will be compounded for SQS-26 ships due to the greatly increased exercise time and exercise control problem for long range detection and attack training. The use of synthetic targets for combined exercises would require a very complex system of calibration and communciation between ships. Thus, it is difficult to provide effective team training and practice among ASW ships in a SAU as frequently as desired for keeping crews at a high level of proficiency. The use of the test set target generator, while adequate for limited one-target procedure practice, cannot generate two independent targets. While other target generation methods, such as a modified test set capability, or taped two target situations may be possible, the training effectiveness of these methods is not known at this time. Therefore, the use of a comprehensive and flexible shorebased trainer appears to be the most assured way for providing effective multi-target training. This type of training is critical for learning to cope with submarine countermeasure devices, such as decoys and false targets.

SURFACE SHIP ASW ATTACK TRAINER, DEVICE 14A2A

(U) The Surface Ship ASW Attack Trainer, Device 14A2A, was planned and designed as a shorebased facility for training the ASW crew of one ship at a time. It provides facilities for training personnel in several stations. These are the Bridge (CONN), Combat Information Center (CIC), Underwater Battery Plotting Room (UB Plot), and the Launcher Captain's Control Station (LCCS). Each of these stations has the necessary simulated operational equipment and communications system equipment to conduct single or multiunit attacks on a submarine. In multiunit problems, one or more instructors control simulated ships and/or aircraft to provide the appropriate inputs and presentations on the radar, sonar, and communications equipment.

(U) Much of the success and acceptance of the 14A2A trainer stems from the realistic simulation of all relevant ASW equipment functions and the readily available and realistic targets, noise, and reverberations presented to sonar. The fire control team can realistically solve for target course and speed and

simulate the firing of ASW weapons. Critical and constructive comments on individual and team performance are provided by objective instructor personnel. These comments and suggestions are invaluable for correcting and improving performance. The trainer provides realistic practical conditions, hostile submarines, opportunity to complete the firing procedures, opportunity to simulate the launch of weapons, knowledge of whether a kill or miss was scored and whether the performance was adequate. Many of these conditions are not available under any circumstances at sea, short of actual war.

(U) The trainer is sufficiently flexible in use to permit a wide range of problem difficulties from very simple to very complex. An example of a simple problem correctly used in Device 14A2A is a nonmaneuvering submarine which is easily detected and tracked on the sonar, and attacked with ASROC or other weapons.

(U) An example of a complex problem is a simulated SAU made up of two support ships and three aircraft, attacking two hostile submarines. In this problem, both submarines may maneuver and fire torpedoes, own ship weapons may misfire or malfunction and repeated attacks and lost contact procedures may be necessary. This level of problem exercises and provides training for the entire ASW team on board one ship.

(U) In multiunit problems the two support ships, the aircraft, and the submarines are controlled by instructor personnel. The instructors supply orders and range and bearing information to Own Ship personnel as if they were stationed on the supporting units. Similarly, they acknowledge information and orders from Own Ship personnel as appropriate. With this arrangement, some training in coordination with other units is provided, such as the ability to vector an aircraft into an attack, to coordinate maneuvers with the two support units, and so on.

(U) Experience has shown that the trainer provides very good training for the Own Ships crew, but only limited training in multiunit or multiship training. For example, the improper and garbled communication from supporting ships which normally adds confusion to the problem is missing as are the errors made by support unit ship operators. In the trainer, the instructors, who function as the support ship's personnel generally provide correct and clear information and use correct procedures. Any subsequent errors which are made in the problem are then due to the trainees themselves and cannot be rationalized as being caused by other personnel.

(C) The trainer presently uses a simulated AN/SQS-23 Sonar System for detecting and tracking the submarine target. This simulated sonar provides audio and visual presentation of target and noise up to 12,000 yards. This possible range can be modified by the instructor in problem setup. The range is ample to permit a coordinated attack by Own Ship and aircraft. When aircraft are included in an attack, the target is tracked by Own Ships sonar and the aircraft are vectored in by Own Ships radar to conduct and attack. Own Ship closes range or stands by to fire ASW weapons after the aircraft have made their attack and have cleared the area.

(U) The relatively good simulation of the SQS-23 Sonar is very effective in providing lost contact search conditions, uncertainty in noise, and variable

detection ranges due to sea state and bathythermal conditions. In the opinion of the Device 14A2A instructors, the realism of the sonar simulation is a major significant factor in providing the excellent motivation of shipboard crews using the trainer. This study contemplates providing an equivalent capability based on the AN/SQS-26 Sonar equipment.

SQS-26 SONAR AND DEVICE 14A2A SYNTHESIS

(U) Several important factors were considered in evaluating the requirements for adding the SQS-26 Sonar capability to Device 14A2A. One of these involved the training objectives of Device 14A2A, both now and in the future. The major mission of Device 14A2A is the training of surface ship ASW teams in the procedures and tactical that apply to the attack phase of the ASW mission. As presently employed, this device is actually used as a combination individual operator and ASW team trainer. This situation appears to result directly from the fact that seldom, if ever, are all members of an ASW team sufficiently proficient in the individual jobs to permit the maximum benefit from a strictly team-training session. As a result, it is often necessary for the instructors to spend a considerable portion of the limited training time working with individual team members and ASW subteams (i.e. CIC, UB Plot, etc.) prior to commencing actual team training. At the present time, the type of training provided to ASW teams in Device 14A2A is determined by a variety of factors, including optional requests by the team itself. Normally, the complexity and type of training that a team receives depends on the ability of the instructors to quickly and accurately diagnose the proficiency of the team. This diagnostic process often indicates the need for individual operator training prior to the commencement of more complex team training exercises.

(U) Due to the complexity of the AN/SQS-26 Sonar System and the extensive program required for training SQS-26 operators, the desirability of providing a facility for training these operators prior to, as well as with the total ASW team was considered. A study of SQS-26 operator skill requirements showed that operators will need extensive individual training before they can fully benefit by team training. A number of solutions were considered as possibilities for providing the necessary operator training, one of which was to utilize a SQS-26 equipped Device 14A2A as a multipurpose trainer. In this case, both SQS-26 Sonar operator training and total ASW team training could be accomplished with a single device. If, however, Device 14A2A is to be restricted to an attack team trainer, a somewhat different approach must be taken in considering solutions to the training program. The goal here was to recommend a training device and the associated training program for the most efficient and effective learning, use of equipment and time of the trainees. Our recommended solution is discussed in Sections V through XII of this report.

(U) The optimum level of equipment simulation for training depends on a number of factors. Research literature in the area of training technology indicate that it is often not necessary to provide complete reality in the simulation of equipment in order to achieve effective training. What matters is the illusion of reality as contrasted with physical reality. Training which employs simulated equipment, however, also depends on trainee motivation. Regardless of how well the illusion of reality is created, if the man who sits at the console does not accept the simulated equipment, and the training situation as being sufficiently like the real world, his acceptance of the training decreases

and so does the effectiveness of the training. Failure of the equipment and situation to function as it would in real life provides a ready excuse for an inadequate performance by the trainee. Consequently, designing a simulated training device to look and act like its real-world counterpart in the eyes of the trainee is one way of insuring trainee motivation, and acceptance of the training.

SECTION II

DESCRIPTION OF THE AN/SQS-26BX SONAR SYSTEM

TYPE OF SYSTEM

(U) The system being considered for incorporation into the 14A2A ASW Team Trainer is the AN/SQS-26BX produced by the EDO Corporation, College Point, New York. The plan is to install this system on 16 ships of DLG, DEG, and DE class hulls.

(U) A later version, the AN/SQS-26CX, is scheduled for installation on 26 additional ships of the same classes. Since the operation, functions, and displays are similar on both the BX and CX systems, the operator tasks and activities should also be similar.

SYSTEM DESIGN

(U) The SQS-26 Sonar System has a much higher performance capability than the SQS-23 and previous sonars. This greater capability has been obtained by using much higher energy transmissions and sophisticated signal processing techniques. This results in the equivalent of three separate systems integrated into one. These systems are (1) a short-range, surface-channel, active echo ranging system (equivalent of an SQS-23 system but with greater range), (2) a long range, depressed-channel, active echo ranging system with convergence zone and bottom bounce capability and (3) a passive detection system. The surface duct channel is known as the Omni channel and the depressed channel is the Uni channel.

(C) In the convergence zone (CZ) mode, the range may extend to 30 miles or more depending on water conditions. In the bottom bounce (BB) modes, detection ranges are achieved which vary from the convergence zone to nominally short ranges of around 10,000 yards, depending on bottom conditions. For close-in coverage, the direct-path surface duct channel is used for ranges from 1,000 to 20,000 plus yards, depending upon the bathythermal layer and other conditions. With this combination of modes and channels, it is expected that the SQS-26 Sonar System will provide complete coverage from about 1,000 to well over 60,000 yards depending on ocean conditions and probability of detection computations. The ranges at which targets may be detected with the SQS-26 equipment is thus several times greater than with SQS-23 equipment.

(U) The SQS-26 system consists of a large, cylindrical transducer with 576 elements housed in a flooded dome. The dome is attached and faired into the bow of the ship. The transmission, reception, signal-processing, and power-supply sections are housed below decks, but are separate from the transducer. Four control and display consoles which present processed sonar returns to the human operator are located in the sonar control room near UB Plot. Operation of these consoles is one of the major concerns of the Human Factors study.

(U) The normal complement to operate the system is three sonar operators and a sonar supervisor. However, in some modes of operation, all consoles need not be manned simultaneously; during Condition One, additional men can be utilized in the sonar room.

MODES OF OPERATION

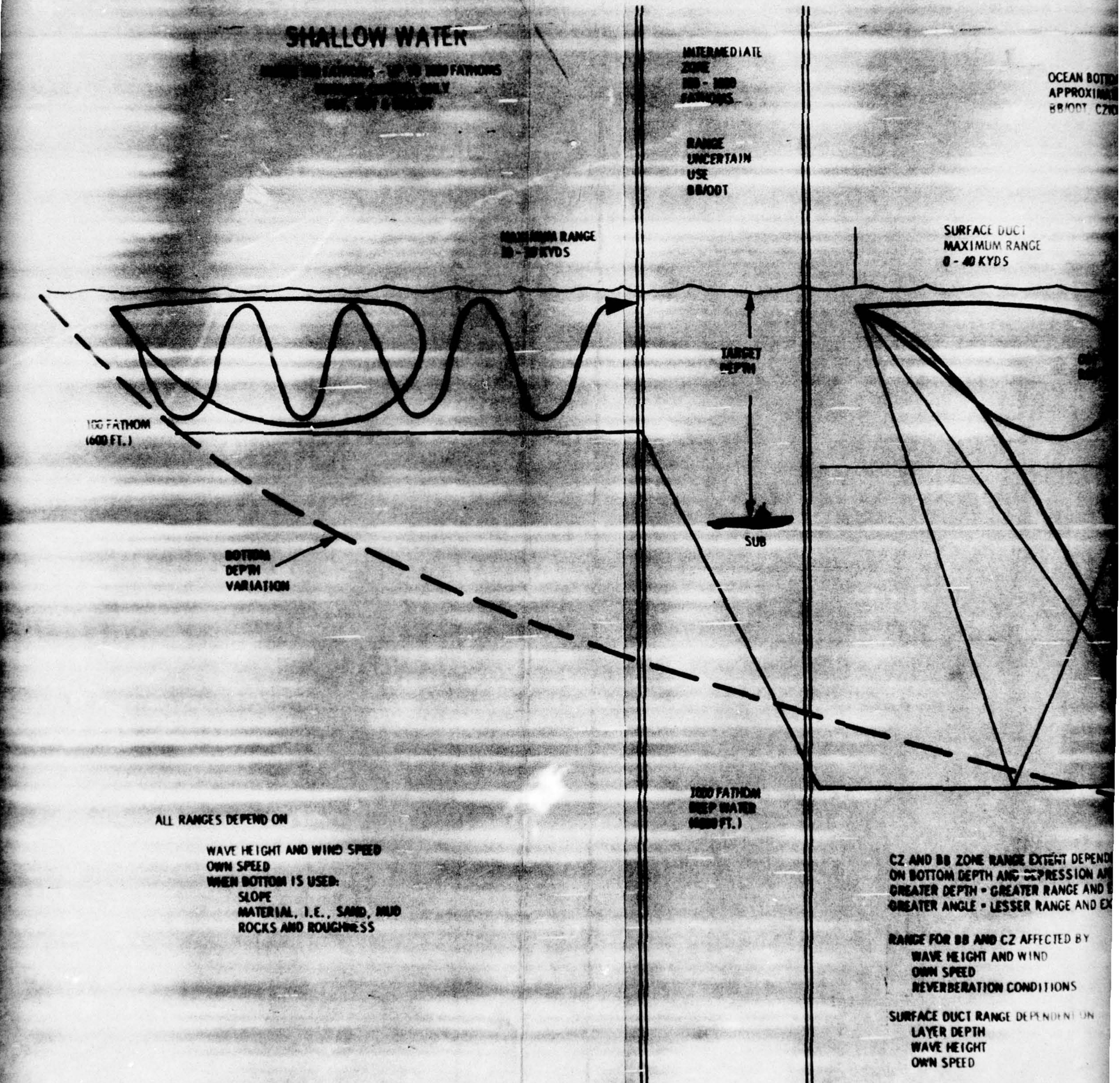
(U) The various modes of operation are especially significant in understanding the SQS-26 system. These modes are described briefly in the following paragraphs and summarized in figure 1 and in tables 1 and 2. These modes are:

1. Depressed Channel
   a. Convergence Zone (CZ)
   b. Bottom Bounce (BB)
   c. Bottom Bounce Track (BBT)
2. Surface Duct
   a. Omnidirectional Transmission (ODT)
   b. Rotational Directional Transmission (RDT)
3. Passive Detection
   a. DIMUS

CONVERGENCE ZONE MODE (CZ)

(C) This is a depressed channel mode of operation, which consists of a 120-degree lateral transmission of sound at a 0, 5, or 10 degrees depression angle. Steeper angles (15, 20, 30 and 42 degrees) although selectable in this mode will deflect the sound transmission to strike the bottom and the convergence zone will not be formed or will be too weak for effective use. In deep water, the transmitted sound paths are bent downward by thermal gradients in the ocean. As the sound passes into depths of greater pressure, it is bent back toward the surface and converges in a zone in the surface layer at variable distances from the source point depending on water conditions. As it reaches the surface layer of warmer water, it is bent downward again into deeper water. The greater pressure again bends the sound upward into a second zone and so on until the sound is lost by spreading or absorption in the water. The first ensonified zone at the surface is from 6,000 to 10,000 yards in extent and over 1,000 feet deep.

(U) Since each transmission covers a 120-degree segment of a circle surrounding own ship, three transmission sectors are required for complete 360-degree coverage. In the BX system, after each transmission pulse in the CZ mode, a separate transmission pulse is made in the ODT surface duct mode for close-in coverage. Also, to speed up the rate of return of data from the convergence zone, three transmission pulses of different frequencies are transmitted in sequence, and timed so that three pulses are in transit to and from the zone simultaneously. By properly timing the signal processing, interference between successive transmissions is avoided.


SHALLOW WATER
INTERMEDIATE ZONE
RANGE UNCERTAIN USE BB/ODT
SURFACE DUCT MAXIMUM RANGE 0 - 40 KYDS
TARGET DEPTH
100 FATHOM (600 FT.)
SUB
BOTTOM DEPTH VARIATION
1000 FATHOM DEEP WATER (6000 FT.)
ALL RANGES DEPEND ON
WAVE HEIGHT AND WIND SPEED
OWN SPEED
WHEN BOTTOM IS USED:
SLOPE
MATERIAL, I.E., SAND, MUD
ROCKS AND ROUGHNESS
RANGE FOR BB AND CZ AFFECTED BY
WAVE HEIGHT AND WIND
OWN SPEED
REVERBERATION CONDITIONS
LAYER DEPTH
WAVE HEIGHT
OWN SPEED

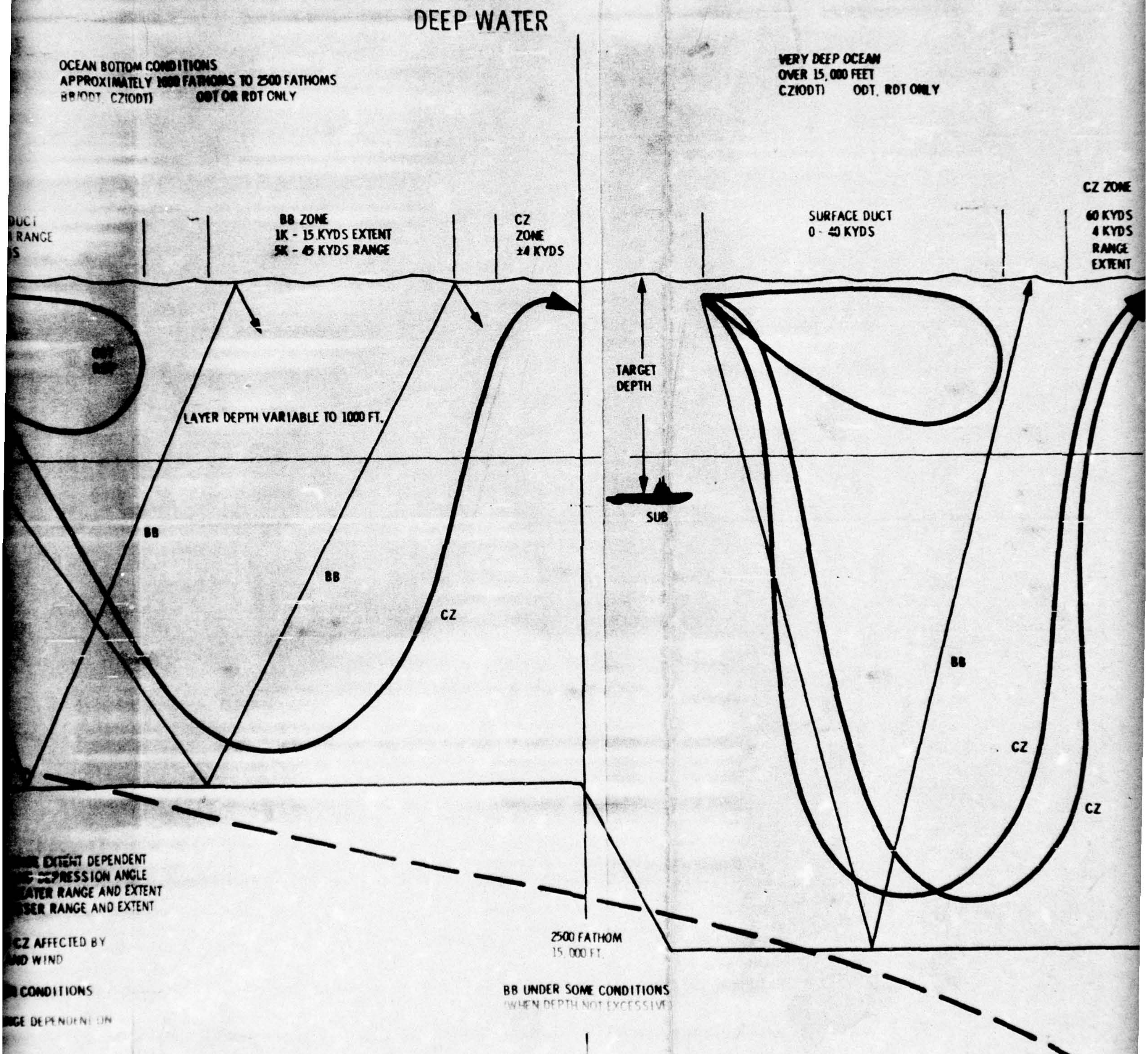


Figure 1. Vertical Coverage, SQS-26 Sonar System

Table 1. Transmission Parameters

TRANSMISSION REQUIREMENTS				TRANSMISSION VARIABLES (PER MODE)			
	INITIAL INPUTS						
Mode	Shallow Sound Vel.	Deep Sound Vel.	Bottom Depth	Sector Center	Sector Width	Zone Start Range	Zone Limits
CZ (ODT)	4800 - 5100 FPS	4800 - 5100 FPS	Must be sufficient to have 30 FPS or more Velocity Excess	Variable 0 - 360°	Fixed 120°	MANUAL/AUTO. If MANUAL, set ZONE START Display to 0-90 Kyds. If AUTO, ZONE START is Computed.	Select 10/20 Kyds Display Range
BB/ODT (BBT)	4800 - 5100 FPS	4800 - 5100 FPS	MAN/AUTO If Manual, 500 - 4000 Fathoms	Variable 0 - 360°	Fixed 120° (3 x 40° Each) (BBT 40° Only)	Select 0 - 90 Kyds for Start of Display. In AUTO, ZONE START is Computed	Select 10/20 Kdys Display Range
ODT	4800 - 5100 FPS	----	----	None (Omni-directional)	Fixed 360°	0 to Natural Limit No Control	Display Set Zero to 2.5, 5.0, 10, 15, 25, 50 Kiloyards Range
RDT	4800 - 5100 FPS	----	----	Variable 0 - 360°	Variable 40° Increments 9 Choices (9 x 40° = 360°)	0 to Maximum No Control	Display Set Zero to 2.5, 5.0, 10, 15, 25, 50 Kiloyards Range

Code

CZ	Convergence Zone
ODT	Omni-Directional Transmission
BB/ODT	Bottom Bounce/Omni-Directional Transmission
BBT	Bottom Bounce Track
RDT	Rotational Directional Transmission
FPS	Feet Per Second
Kyds	Kiloyards
CP	Coded Pulse
CW	Continuous Wave
PPI	Plan Position Indicator
GI	Graphic Indicator
FM	Frequency Modulated
PRN	Pseudo Random Noise
MS	Millisecond
KC	Kilocycle (band)
SSI	Sector Scan Indicator
A-Scan	Vertically oriented di… Vertical sweep shows … Horizontal shows bea…
B-Scan	Vertically oriented di… Vertical - range Horizontal - …

Transmission Parameters						
MODE)						
Start Range	Zone Limits	Depression Angle	Pulse Type	Pulse Length (milliseconds)	Pulse Frequency	XMTR Power Level
AL/AUTO. NUAL, set START Dis- o 0-90 Kyds. TO, ZONE T is Com-	Select 10/20 Kyds Display Range	3 Choices: 0°, 5°, 10° (15°, 20°, 30°, 42° Selectable but not Effective)	CP + CW / FM/PRN for CP	Fixed (500 CP+480 CW)x 3 + 300 ODT in Sequence of 3 Frequencies	All 3 in Fixed Sequence	Choice of One of Eleven Levels (Reduced Power)
0 - 90 Kyds art of Dis- In AUTO, START is uted	Select 10/20 Kdys Display Range	4 Choices: 15°, 20° 30°, 42° (0°, 5°, 10° Permitted)	CP + CW / FM/PRN for CP	Fixed (500 CP+480 CW)x 3 + 300 ODT BBT (500 + 10 CW)	Choice of 3: (1) 3.15-3.05 Band (2) 3.45-3.35 Band (3) 3.75-3.65 Band in KC Nominal	Choice of One of Eleven Levels (Reduced Power)
atural ontrol	Display Set Zero to 2.5, 5.0, 10, 15, 25, 50 Kiloyards Range	0° Only	CW Only	30, 100, 300, 1000 ms	Choice of 3: (1) 3.25 KC (2) 3.55 Kc (3) 3.85 Kc	Choice of One of Eleven Levels (Reduced Power)
Maximum ontrol	Display Set Zero to 2.5, 5.0, 10, 15, 25, 50 Kiloyards Range	0° Only	CW Only	30, 100 ms in All Widths 300 ms in 40, 80, 120° Widths Only, Sequential Xmit	Choice of 3: (1) 3.25 Kc (2) 3.55 Kc (3) 3.85 Kc	Choice of One of Eleven Levels (Reduced Power)

Frequency Modulated
Pseudo Random Noise
Millisecond
Kilocycle (band)
Sector Scan Indicator
an Vertically oriented display for BB & CZ modes
Vertical sweep shows range
Horizontal shows bearing
an Vertically oriented display for ODT & RDT modes
Vertical - range
Horizontal - bea...

Table 2. Reception Parameters

RECEPTION PARAMETERS									
Operator	Primary Mode	Scopes	Audio	Sound Range	Bearing	Horizontal Range	Range Rate	Target Depth	Reverberation Notch
A-Scan Operator	CZ (Echo Trap Utilizaion) BB (Echo Trap Utilization) BBT	A-Scan Z(Ra) Display	Recorder Beam Select 1 of 3: Left, Center, Right B-Scan Audio	Digital Readout	Digital Readout	Dial Readout	----	Scope Display and Dial Readout	Select In/Out
B-Scan Operator	ODT RDT	B-Scan PPI	Single/Multi Beam Select A-Scan Audio	Digital Readout	Digital Readout and PPI Dial Readout	----	----	----	Select In/Out
Tracking Console Operator	Echo Trap and Track (All Modes)	SSI GI	Recorder Beam Select 1 of 4: Left Inner Left Outer Right Inner Right Outer	Digital Readout	Digital Readout	----	Digital Readout (GI Display)	----	----
Supervisor	DIMUS	Passive Recorder	Passive Bearing		Dial Readout				

ception Parameters

						OPERATOR SELECTIONS	
al	Range Rate	Target Depth	Reverberation Notch	PPI	Echo Trap	Mode Select	XMIT Selection
	----	Scope Display and Dial Readout	Select In/Out	----	Initiate	Power On XMTR On Recycle 1 of 5: CZ, BB/ODT, BBT RDT, ODT Pos Keep Aided Track On Target Search/Track Echo Trap	Sector Center Zone Limits Depression Angle FM/PRN Pulse Frequency Select for All Modes Except CZ Cursor Position
	----	----	Select In/Out	Select Sum/ Diff	----	Recycle (ODT & RDT Only) Pos Keep Aided Track On Target Search/Track	Sector Center RDT Only RDT Sector Width Displayed Range Pulse Length ODT & RDT Only XMTR Power Level Cursor Position
	Digital Readout (GI Display)	----	----	----	See, Hear Analyze and Erase	SSI On SSI Off SSI Aided Track Recycle Uni/Omni Channel Select (A-Scan - B-Scan Choice)	Cursor Position in SSI Mode

(U) Convergence zone ranging with sonar is dependent upon ocean depth. If ocean depth is insufficient the sound waves will strike the bottom and be reflected. When the ocean is sufficiently deep that the bottom will not interfere, a convergence zone will exist. However, reverberation and noise from the zone due to wave action, deep water movements, and biological organisms may prevent signal detection. Also, the range to the zone and the zone width are not controllable factors, but are fixed by existing ocean conditions (see figure 1). The control of the system in this mode is accomplished at the A-Scan console. The A-Scan displays the primary return from the convergence zone. When the tracking console is switched to A-Scan, CZ returns are displayed on the SSI and GI also.

BOTTOM BOUNCE MODE (BB)

(U) This is the second depressed channel mode of operation, and is similar to the CZ mode. However, the transmissions are directed at steeper depression angles of 15, 20, 30, or 42 degrees. The shallower angles (0, 5, and 10 degrees), while selectable, in this mode are only usable under unique conditions. This directs the sound towards the bottom, and when the bottom conditions are favorable the sound will be reflected (or bounced) back to the surface. Upon reaching the surface the sound will be reflected back towards the bottom. The bottom, the surface, and objects in the water will all reflect and reverberate sound back to the transducer.

(U) Two bottom bounce modes are available: a Bottom Bounce Track (BBT) mode and a combined Bottom Bounce and Omnidirectional Transmission in the surface duct (BB/ODT). The BBT transmission consists of one pulse, 40 degrees wide, and is intended primarily to obtain target depth information. The BB/ODT transmission consists of three 40-degree wide transmission pulses, in sequence, for 120-degree coverage. These three pulses are then followed by one omnidirectional pulse for 360-degree coverage in the surface duct.

(U) Both CZ and BB modes utilize fixed pulse lengths of Coded Pulse (CP) and Continuous Wave (CW) transmissions. In addition, the coded portion can be either Frequency Modulated (FM) or Pseudo-Random Noise (PRN).

(U) Bottom depths greater than 1,000 fathoms are necessary for effective use of this mode. Bottom depths less than 100 fathoms are considered shallow water, and create the equivalent of a surface duct for long range detection when this mode is used. Bottom conditions must be favorable for the use of BB mode in shallow water. Bottom depths between 100 and 1,000 fathoms create uncertain conditions.

(U) The range of the ensonified zone of the bottom bounce transmission is controlled by selection of the depression angle and display range controls. The geometry indicates that the shallower depression angles will yield the longer ranges, and that steeper angles will permit detection at closer ranges. The main objective with bottom bounce is to ensonify the ocean areas between the long range CZ ring and close-in detection via surface duct direct path reception. This permits detection in ocean areas where the bottom depth prevents use of the convergence zone mode.

(U) Bottom depth, make-up of the bottom, its smoothness, and its slope all affect bottom bounce usage. Bottoms of mud and silt tend to absorb more sound than sandy bottoms. Rocks, ridges, pinnacles, and other rough terrain on the bottom tend to scatter the sound. Slopes greater than 3 to 6 degrees deflect sound waves at various angles and cause erroneous range and bearing indications.

A-sc.

(U) Figure 1 shows a summary of BB sonar operation. This mode of operation is controlled at the A-Scan Console, and the return is displayed on the A-Scan. The SSI and GI also display returns from the BB sector.

OMNIDIRECTIONAL TRANSMISSION MODE (ODT)

(U) The omnidirectional pulses are always transmitted at a 0-degree depression angle, and provide a full 360-degree coverage around the transducer in the surface duct channel. These transmissions occur in conjunction with the CZ and BB transmissions, or independently in the ODT mode. In the CZ and BB modes, the timing and frequency of the transmission is controlled by the CZ or BB mode selected (time required for sound to travel to the desired area and back). But in the independent ODT mode the pulse frequency, pulse length, and range of interest can be controlled by the B-Scan Console operator.

(U) The omnidirectional transmission mode is similar to the type of transmission used by the SQS-23 and other active sonars, but improvements in design provide longer range capability. As with other sonars, detection range depends on bathythermal layer conditions; the deeper the layer the greater the range of the sonar in the surface duct mode. However, with the SQS-26 sonar, greater efficiency permits longer direct-path coverage than with other sonars under the same ocean layer conditions.

B-sc.

(U) Transmission in the independent ODT mode is controlled by the operator at the B-Scan console. Two primary displays are used to display returns in the ODT mode. These displays are (1) a typical 7-inch PPI display, and (2) a 17-inch CRT, called the B-Scan display. These displays are described later in this section. When the tracking console is switched to B-Scan, the Sector Scan Indicator and Graphic Indicator display returns from the surface-duct channel.

ROTATIONAL DIRECTIONAL TRANSMISSION (RDT) MODE

40°–360°

(U) The RDT mode is an independent mode that uses the surface channel in the same manner as the ODT independent mode. In RDT, the operator can narrow the transmission to multiples of 40-degree sector widths rather than using the full 360-degree coverage in ODT. This permits a higher power level to be used in one sector. The transmissions are made sequentially in 40-degree sector widths, permitting the operator to improve reception by limiting side lobes and broad sector reverberations. The operator can select a sector width and then center this sector on any azimuth with the cursor control. This mode of operation is controlled by the B-Scan Console operator, and the echoes are displayed on both the PPI and B-Scan CRT, and Sector Scan Indicator and Graphic Indicator.

B-scan

PASSIVE MODE

(U) The passive mode of the SQS-26 uses selected elements from the transducer continually, and receives lower frequencies to avoid interference from the active modes.

(U) The DIMUS passive receiver and paper recorder display permit bearing detection of all continuous noise sources in the ocean, including ship sounds and torpedo tracks. Background noise is displayed on the paper recorder as a uniform gray, and noise source bearings are displayed as darker spots and lines. A coordinated audio and trainable scan switch permits the operator to select the bearing of noise source accurately, and to make limited classification decisions based on the passive audio sounds.

OPERATOR CONSOLES - 4

(U) Four operator consoles as shown in figure 2, are used in the operation and control of the SQS-26 equipment. An additional console is used in setting up and testing the operation of the system. Each console is described briefly to identify its primary function, and the characteristics of its main control and display features. A complete description of all controls and displays on these five consoles is given in Appendix A.

THE A-SCAN CONSOLE

(U) The A-Scan console is primarily associated with the depressed channel and is used when the system is in the CZ and BB modes. It can be used for surface channel detection under unique conditions. It also contains the main system controls and mode select switches. The face plates for the top, center, console and shelf panels are shown in figures 3 and 4.

(U) The primary display area on the console is the A-Scan CRT shown in figure 5. This 17-inch CRT is electronically split into three sections. The right-hand portion of the screen displays the 12 channels (10 degrees each) of Continuous Wave (CW) signal information, and the center portion displays the 12 channels (10 degrees each) of Coded Pulse (CP) information. Two channels of combined (ORed) information are shown along the left-hand margin of the screen. These two ORed channels combine and sum all signal information shown in the 12 CW and 12 CP channels respectively as a monitoring aid.

(U) Each of the 26 channels displays six successive range sweeps of information in UNI search. Displaying each sweep simultaneously side by side permits the operator to readily observe the ping-to-ping correlation of echoes. Each displayed echo is accentuated by both amplitude deflection and brightening of the return.

(U) A cursor joystick, located on the console shelf, is used to position the range and bearing cursor on the A-Scan display. This cursor also controls the selection of the ocean sector for ensonification.

(U) The operator of the A-Scan console selects the desired mode of system operation and the minimum range and width of the zone to be displayed. He then initiates the transmission program. As the return is displayed on A-Scan,

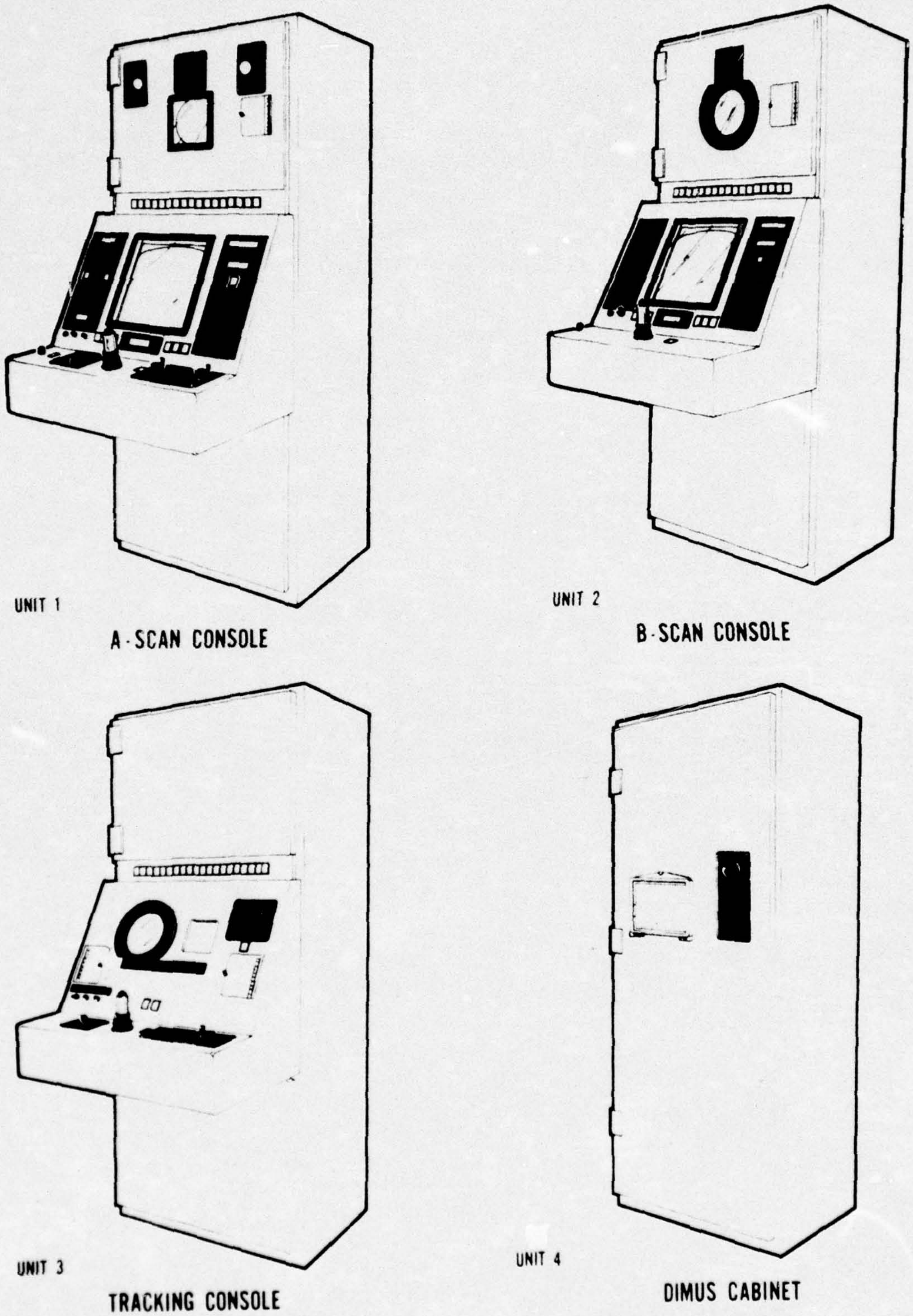


Figure 2. SQS-26BX Operator Consoles

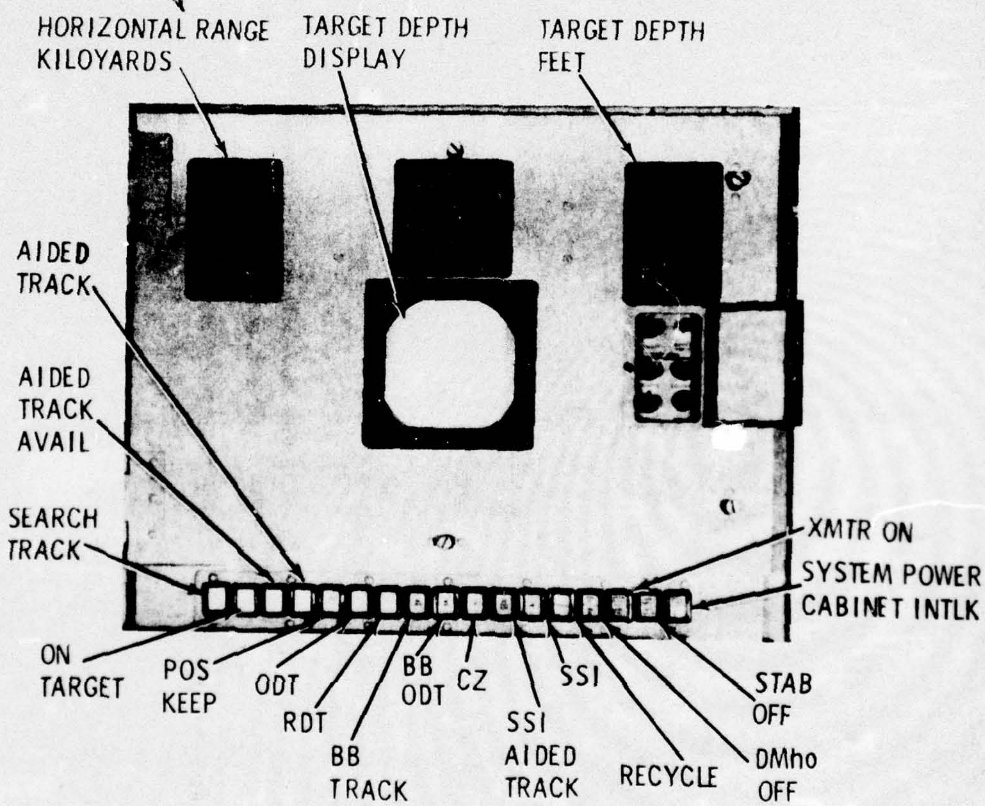


Figure 3. Top and Outer Control Panel of A-Scan Console, Unit 1

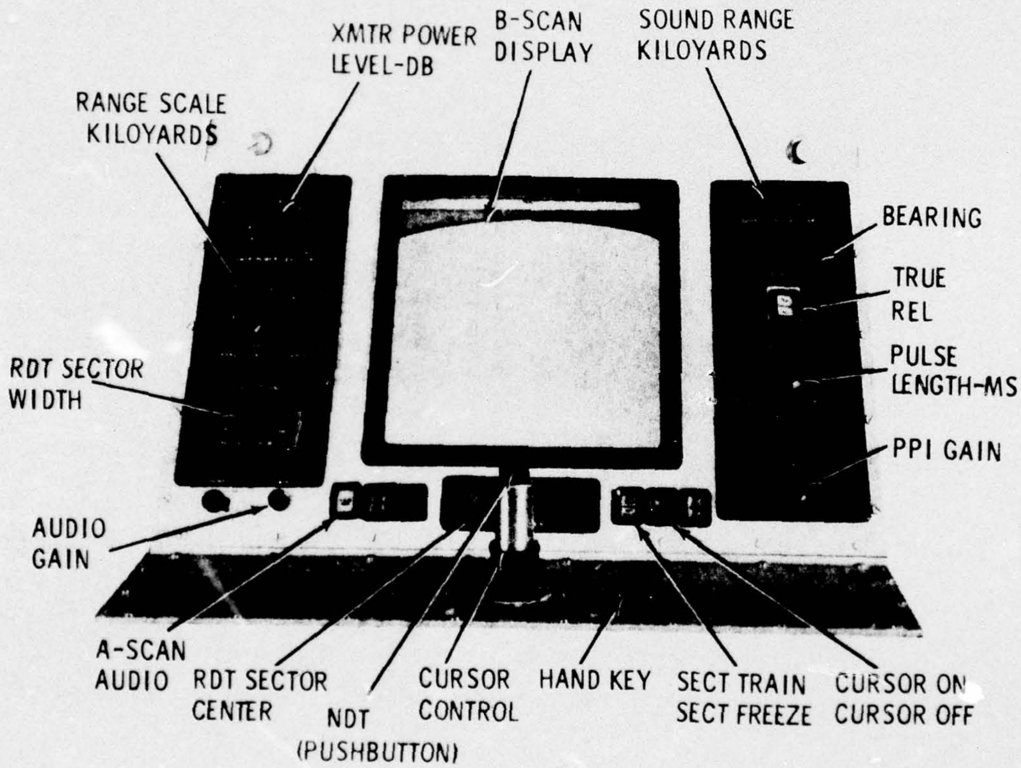


Figure 4. Console Panel and Shelf of A-Scan Console, Unit 1

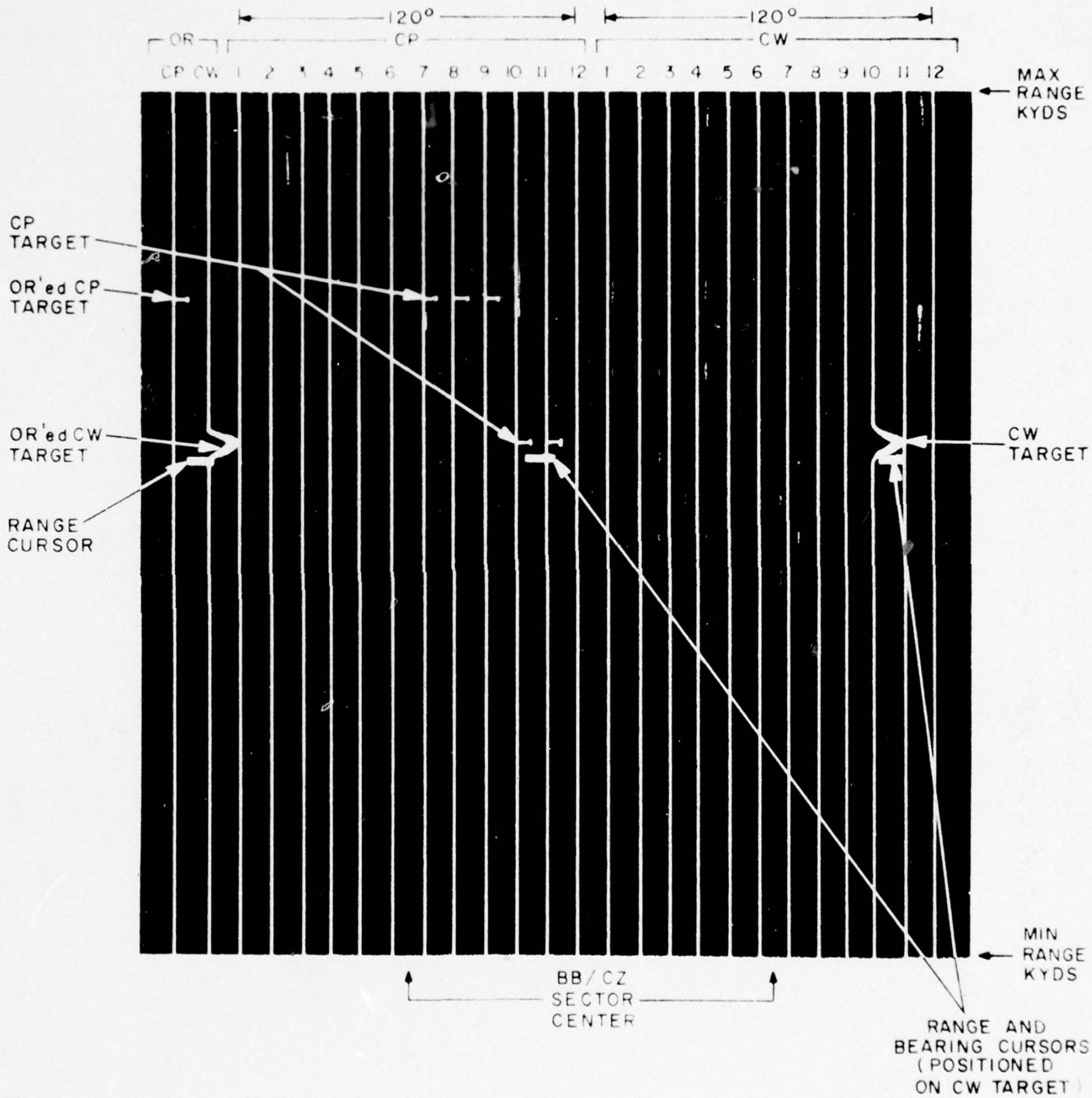


Figure 5. A-Scan Display (Reproduced from AN/SQS-26BX Operator's Manual NAVSHIPS 0967-0011-6020, Page 1-13)

he attempts to detect a target by observing the sweeps on the two OR channels, on the 12 CP channels, and on the 12 CW channels.

(U) When in the UNI search mode and a possible target echo is observed, the operator centers the cursor on the echo bearing and range, and positions the AUDIO RECORDER BEAM SELECTOR to the group of 4 channels (left, center, or right) that contains the echo. On the next echo return, he presses the ECHO TRAP switch, causing the echo to be recorded for analysis by the tracking console operator.

(U) The accuracy of cursor positioning is limited in bearing to a 10-degree channel. Accuracy of positioning in range depends upon the choice of displayed zone width and may be accurate to 100 or 200 yards.

THE B-SCAN CONSOLE

(U) The B-Scan console is used to control the transmission in the surface duct channel. The B-Scan Console contains two major displays, the B-Scan CRT and a standard PPI. Both the CRT and the PPI display returns from surface channel transmissions. The selection of mode, as for all modes, is made at the A-Scan console.

(U) The B-Scan console (figures 6, 7, and 8) has controls for selecting pulse length, range scale, and transmitter power level. An RDT SECTOR WIDTH selector permits selection of 40, 80, 120 (and on to 360) degree RDT sectors for ensonification. The sector center is selected by the cursor control, which also positions the cursors on the PPI and B-Scan displays.

(U) The PPI display is the same type of 7-inch CRT display used with other current sonars. A switch permits the operator to choose either PPI SUM or PPI DIFF for search or track operations.

(C) The B-Scan display (figure 8) is a 17-inch CRT that presents an X-Y plot of range and bearing. Range is shown vertically with minimum range at the bottom of the screen and maximum range at the top. The maximum range is selectable from 2.5 to 50 kiloyards. Bearing is displayed horizontally with the 0-degree bearing in the center. Seventy-two channels of 5 degrees each are displayed on the scope with 36 channels or 180 degrees extending to either side, respectively. Three successive returns are stored and displayed for each 5 degree channel. Targets and other echoes are displayed by brightening only.

(U) The operator can position the cursor on an echo by observing its position on either the PPI or the B-Scan display or a combination of both. By using the PPI, bearings can be judged to within 1 degree, compared with the 5-degree limit on the B-Scan. However, range can be judged much more accurately on the B-Scan display than the PPI because of its larger size. Still greater accuracy in range and bearing can be achieved with the SSI display on the tracking console.

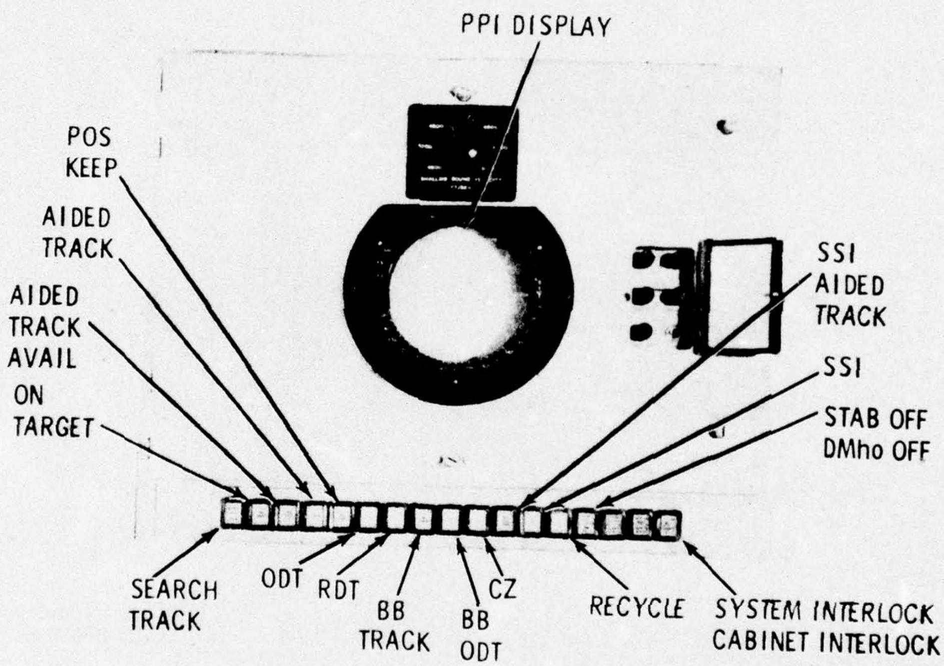


Figure 6. Top and Center Control Panel of B-Scan Console, Unit 2

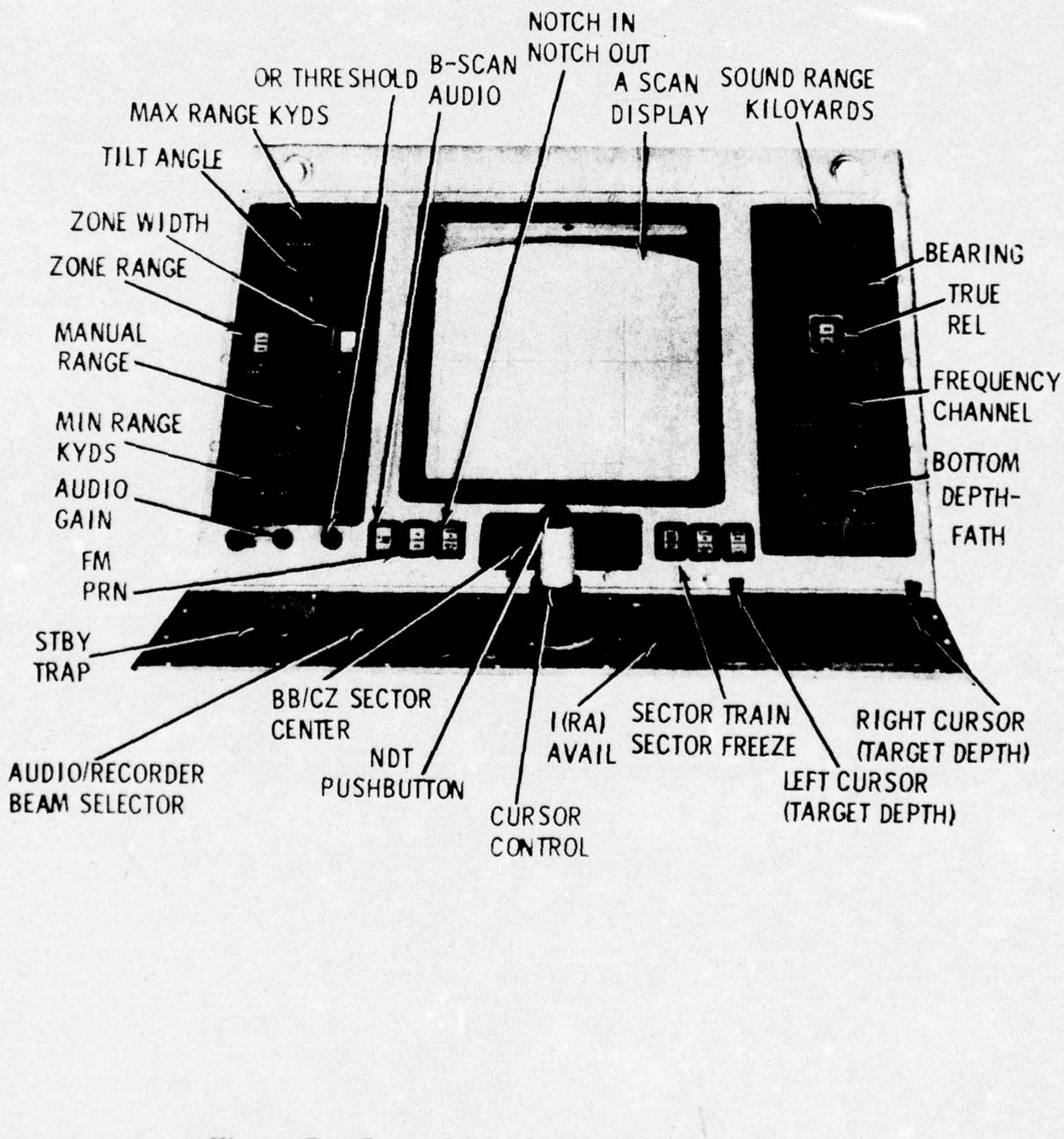


Figure 7. Control Panel and Shelf of B-Scan Console, Unit 2

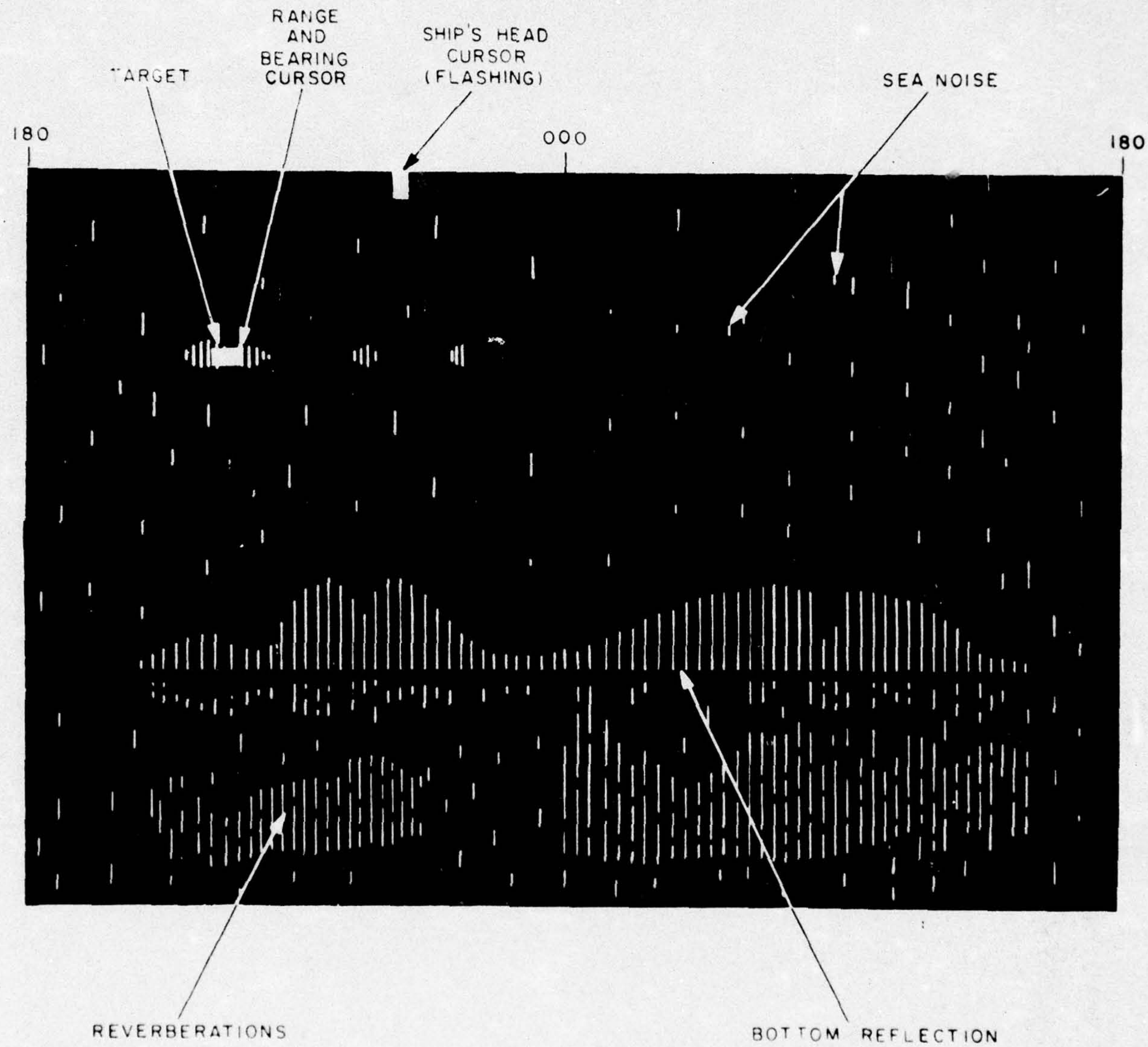


Figure 8. B-Scan Display (Reproduced from AN/SQS-26BX Operator's Manual NAVSHIPS 0967-0011-6120, Page 1-17)

THE TRACKING CONSOLE

(U) The tracking console is used in conjunction with both the surface duct and depressed channels, and in coordination with both the A-Scan and B-Scan consoles.

(U) The tracking console has two primary displays, a cursor control, and several other controls. The two major displays are the Sector Scan Indicator (SSI) and the Graphic Indicator (GI) figure 9. The control panel, console panel, and shelf are shown in figure 10.

(U) The SSI provides an 8.5 degree (Nominal ±5 degrees) bearing increment and a ±1,000-yard range increment centered about the position of either the A-Scan or B-Scan cursor. The console operator selects the desired channel and console, and observes the ensonified area at the cursor position. Since the SSI display provides a greatly expanded view of the cursor position, the tracking operator can determine target position much more accurately than the A-Scan or B-Scan operators. The tracking console operator can accurately position the cursor on the target only when the SSI console is activated. When target range and bearing data is to be transmitted for a fire control solution this accurately-fixed cursor position is normally used.

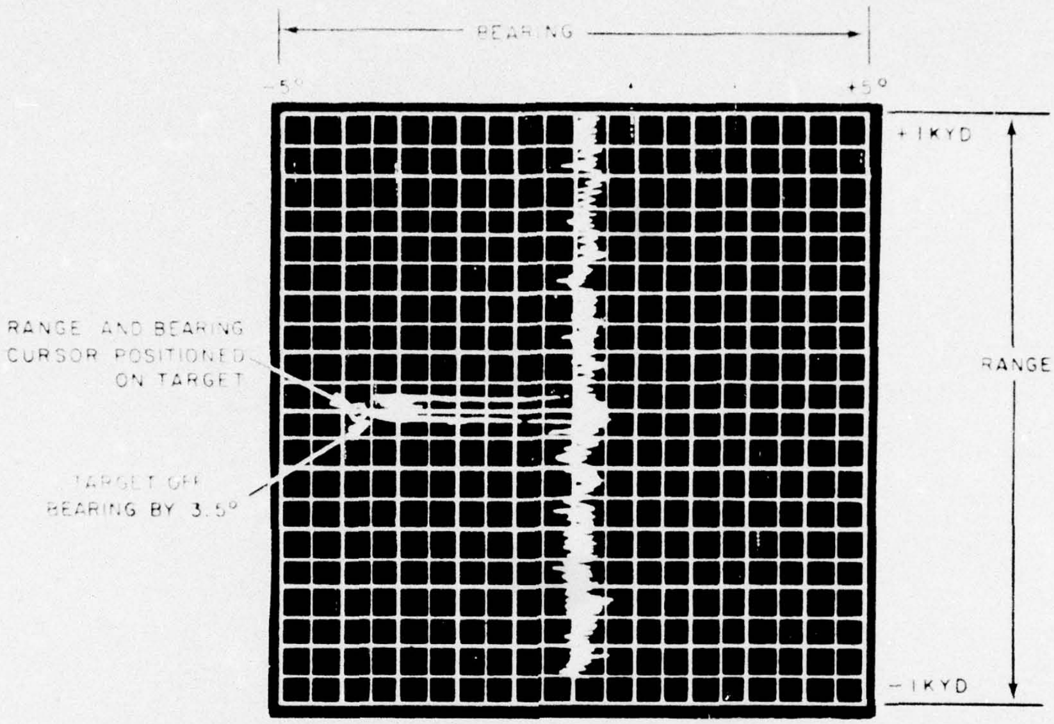
(U) When the A-Scan console is selected and the system is in the search mode, all return signals trapped by the A-Scan operator in the echo trap are displayed on the graphic indicator. By manipulating the range rate handknob, the tracking console operator can align the displayed echo in a series of vertical lines that automatically determines the apparent range rate versus range of the echo. This range rate is displayed as knots of closing or opening range, and is a good classification aid for the operator. In the track interval, the GI display shows range rate automatically for each successive return. Each return is recorded and repeatedly displayed on the GI for analysis. After the operator determines the range rate with the handwheel, it is used in the SSI aided track interval to help to keep the cursor centered on the target.

(U) When the tracking console is switched to the B-Scan console, the GI display also shows the range rate of the target centered at the cursor position. This range rate indication is also one of the key classification aids in the surface duct.

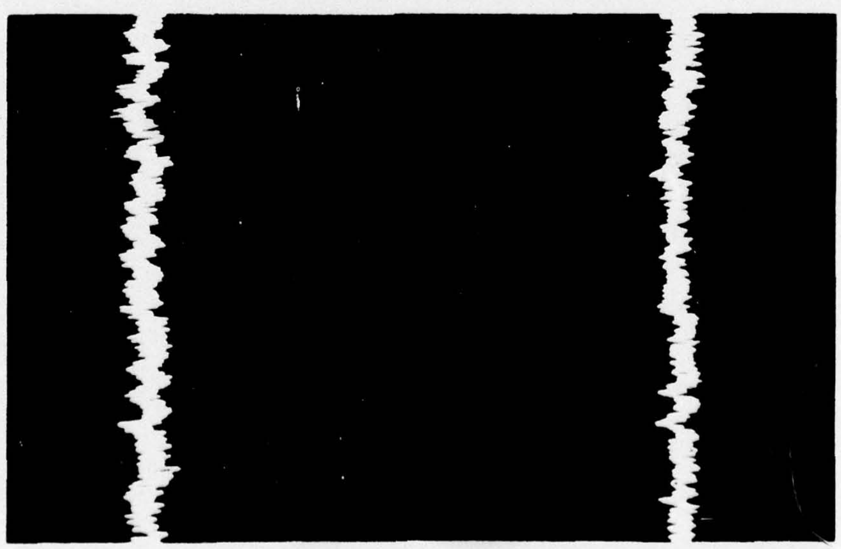
(U) By using the SSI and GI displays in conjunction with each other, the tracking console operator can track and classify possible contacts much more accurately than either the A-Scan or B-Scan operators. Consequently, when an echo has been detected, the tracking console is energized so that the tracking console operator can help make classification decisions.

THE PASSIVE CONSOLE

(U) The passive console is housed in a simple upright cabinet with a control panel as shown in figure 11. A paper tape recorder is visible in the front panel of the cabinet. When turned on, the paper tape runs continuously at a rate of 1 inch per minute. A servo-driven recording pen is positioned laterally over the paper, and is activated by signals from every other element in the



SSI DISPLAY



GSI DISPLAY

Figure 9. Tracking Console Display (Reproduced from AN/SQS-26BX Operator's Manual NAVSHIPS 0967-0011-6020, Page 1-19)

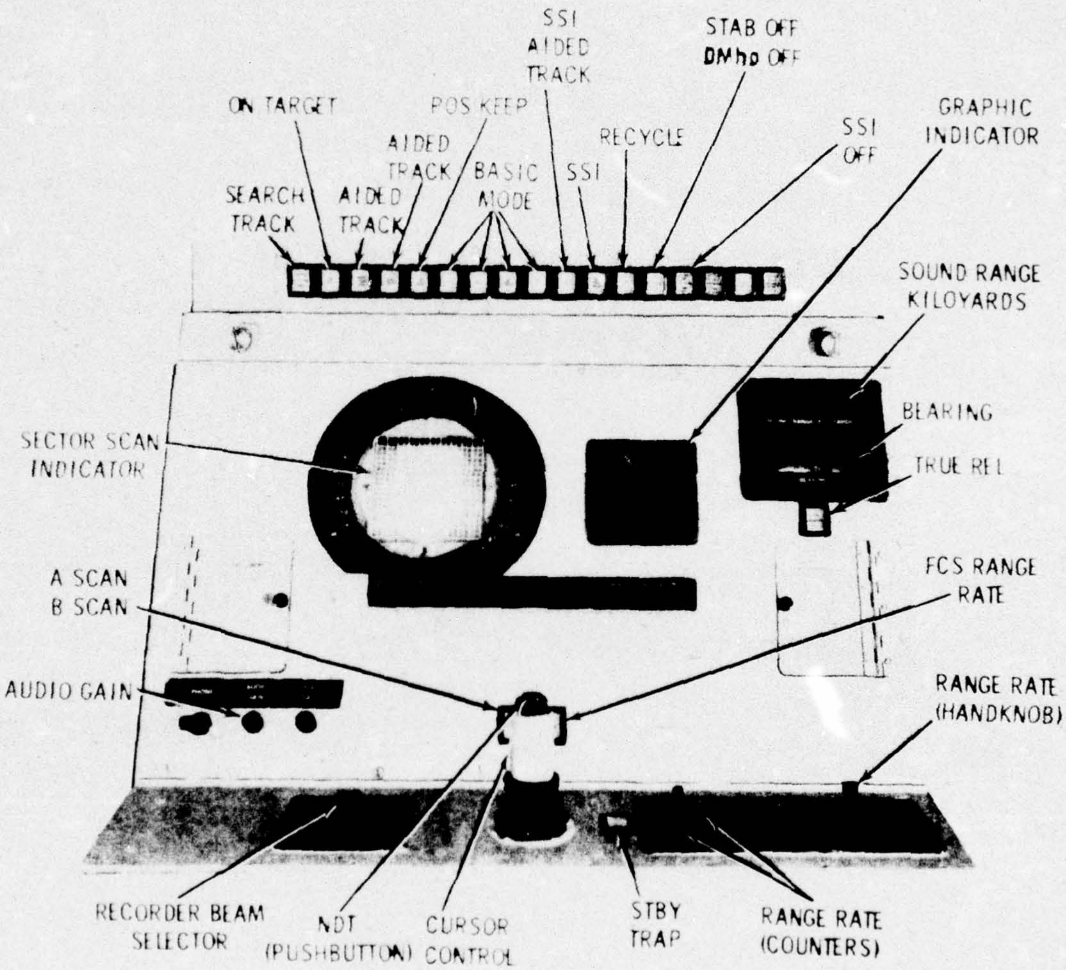


Figure 10. Control Panel, Console Panel and Shelf of Tracking Console, Unit 3

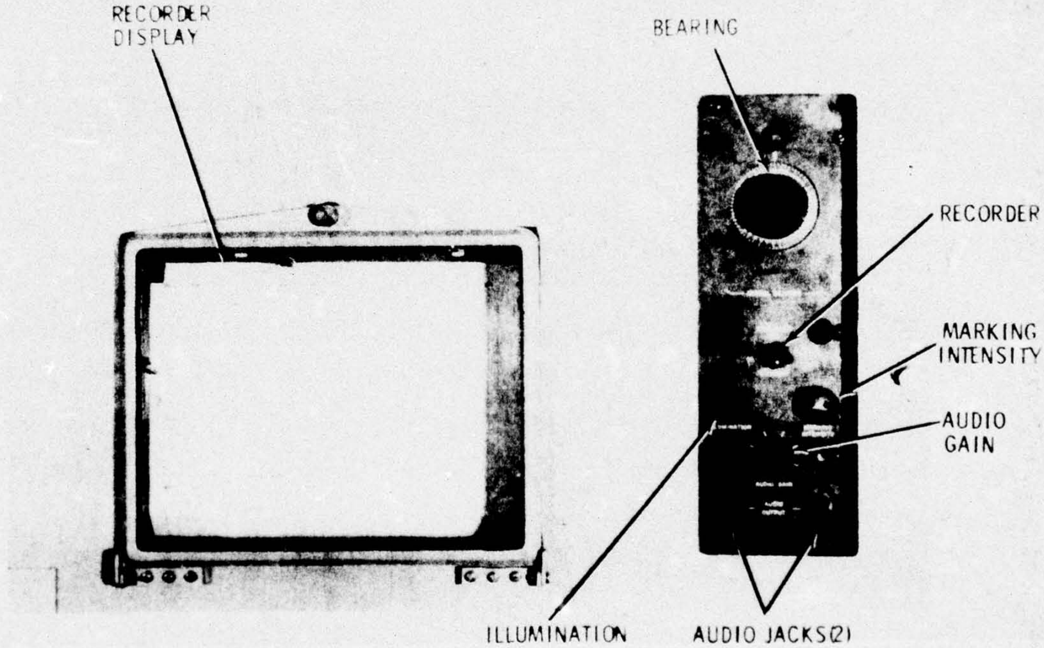


Figure 11. Control Panel of Azimuth Recorder, Unit 4

transducer at the 0-degree depression angle. The full width of the paper tape represents the 360-degree relative bearing passive listening sector. When an observer notes a suspicious trace on the recording, he can connect his earphones and select the bearing for listening to the sound causing the trace. Since this is a passive noise detecting recorder and amplifier, in some cases the observer may be able to classify the sound from its audio characteristics.

THE TEST SET CONSOLE

(U) The Test Set Console is used for equipment maintenance and system checkout, and to determine the optimum operational settings for using the equipment. It is housed in an upright cabinet with a control panel as shown in figure 12. It has the capability of inserting a simulated target into the system, which can be observed on the various console displays. If the target cannot be detected, this indicates that the system is not functioning properly or that the sea noise and reverberation levels are too great for signal detection in the mode or range selected.

(U) The Test Set Console is used at the beginning of each watch to check system operation and to make the necessary adjustments in equipment settings. Except for this, the console is turned off as it is not used in actual sonar operation.

INTERFACE WITH THE FIRE CONTROL SYSTEM

(U) The SQS-26 Sonar System is electrically connected to the Fire Control Switchboard (FCS) in the fire control station or UB Plot. The A-Scan, B-Scan, and tracking consoles are connected so that any console can supply information to the fire control system. The various switch positions on the sonar consoles and Fire Control Switchboard enable the appropriate range and bearing data from the cursor positions to be displayed on the Mk 53 plotter. Cursor positions selected by the A-Scan and B-Scan operators provide only a coarse location of the echo while very accurate range and bearing data can be generated by the cursor position of the tracking console.

(U) After each sonar return, new data on range and bearing is transmitted to the FCS when the operator presses and releases the new-data-time switch. Successive cursor positions are displayed on the Mk 53 plotter as target positions, and when the plotter operator aligns his cursor and speed shadow, this data is entered into the fire control computer for determining weapon aiming and firing data. The accuracy of cursor positioning by sonar is the primary factor for determining accuracy throughout the system. Accurate data from sonar permits target motion solution and accurate weapon aiming.

(U) In the current plans, the SQS-26 can be used only with the MK 114 FCS, which includes the Mk 53 Attack Console. Accurate plots will be obtained only from the surface duct channel via the B-Scan and tracking consoles. This is due to the lack of a slant range computation capability in either the Mk 53 or the SQS-26. However, this is not expected to be a problem because of the longer range detection in the surface duct anticipated with the SQS-26, and the relatively limited range of the ASROC weapon.

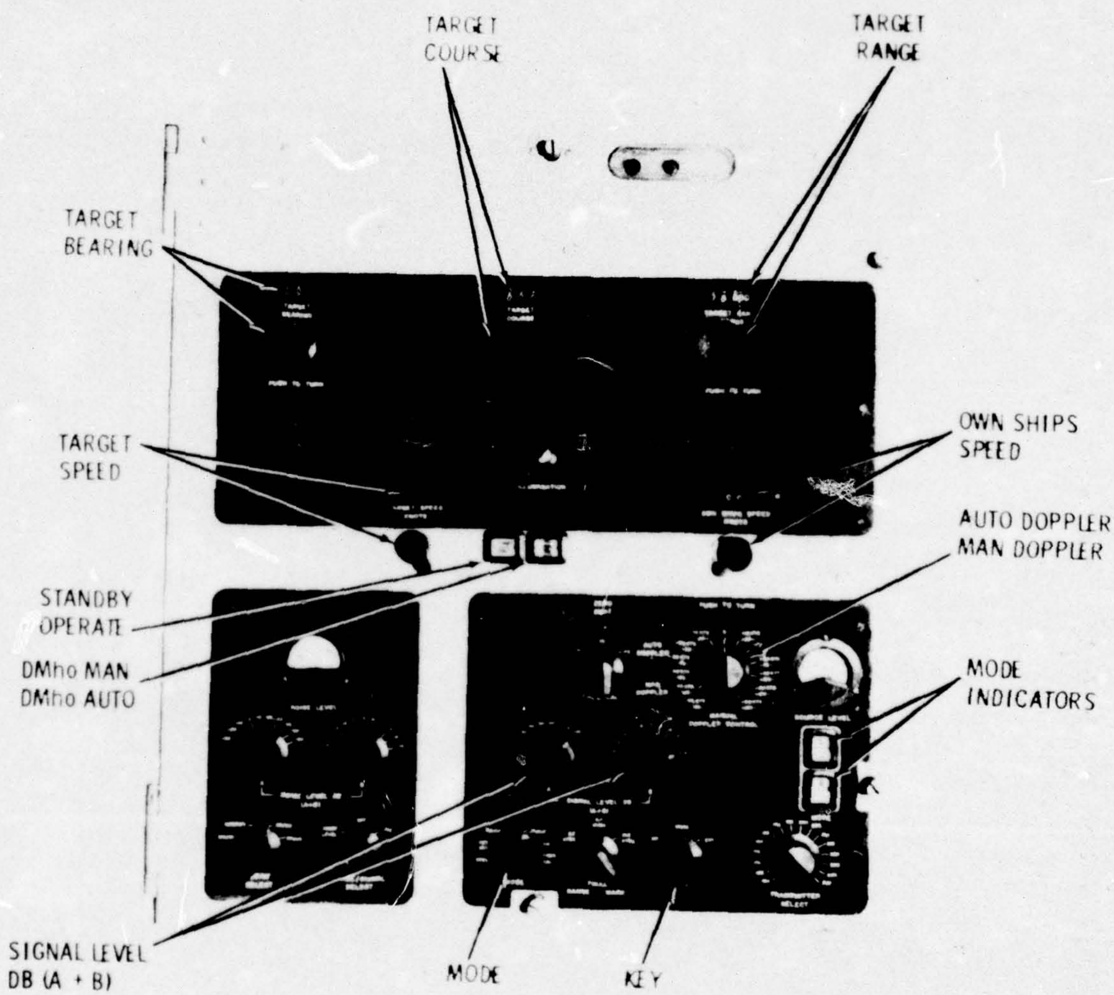


Figure 12. Control Panel, Test Set Console, Unit 5

(C) All CZ target detections are beyond current weapon ranges and BB detection within weapon range will occur only rarely. However, echoes detected in the BB mode can be tracked and plotted on the Mk 53 plotter even though the actual range is inaccurate. This is possible because the units are wired together through the Fire Control Switchboard. Plotting targets detected on BB on the Mk 53 plotter is desired to aid classification, and to allow use of the position keep mode to search for a lost contact. Later modifications may provide a slant range computation capability and resulting accurate range determination, as well as target course and speed computations for BB mode. This will permit accurate ranges, target course and speed computations to be generated out to 40,000 yards. Major modifications in the Mk 53 equipment will be necessary for the use of ranges greater than 40,000 yards.

(U) With the current design, the horizontal range dial on the A-Scan console is not functional. The plan was to provide the readout to the A-Scan operator fromthe Mk 53 computer. But, since the slant to horizontal range is not computed, horizontal range computed from data available in the depressed channel is inaccurate. Therefore, the indicator is not connected.

(U) A possible future modification may make the horizontal range computation (Rha) available in the sonar equipment so that it can be displayed.

(U) Range rate is now available on the tracking console and is electrically connected to the fire control switchboard. However, no equipment is provided to use this data in the Mk 53 computer. This interface is also nonfunctional.

(U) Target depth information can be obtained in the BBT mode with the SQS-26 equipment. While part of the equipment required to determine, transmit and utilize this information is included in the system design, some components are missing in the current configuration. Consequently the BBT mode is not completely functional, and this interconnection between the SQS-26 and Mk 53 is not completed. The BBT mode can be used to obtain a display on the target depth PPI. This display will show multiple echoes if the target is submerged although the equipment to determine depth is not provided.

(U) While a passive bearing signal is available on the DIMUS console, there is no provision to utilize this data in fire control. This interconnection, is also not included in current designs.

ENVIRONMENTAL FACTORS

(U) The operation of the SQS-26 Sonar is dependent upon and greatly affected by many environmental factors. In an operational situation these factors are measured and recorded, and the system is adjusted to the limitations imposed by the environment. The environmental conditions that influence operation of the SQS-26 were found to be the layer depth, the sea state, bottom parameters and biological factors. Each of these factors were analyzed to determine its effect on the operation of the sonar. The layer depth was found to severely limit the range of detection in the Surface Duct mode but had little effect on the BB and CZ modes. Sea state was found to affect reception in both Surface Duct and Depressed Channel operation and becomes critical during higher sea states. The bottom composition, and depth are critical for use of the BB mode of operation. Bottom depth has a significant effect on range in the BB mode.

Bottom slope and tilt, while not affecting reception have a significant effect on the range and bearing indications of the target since both parameters deflect the sound beam. The exact return of biological factors is not completely known but does affect reception.

ADVERSE CONDITIONS OF OPERATION

(U) The conditions under which the SQS-26 will be operated at sea will be similar to the operating conditions for present sonars on other ships. The adverse conditions, especially in high seas, of a moving, pitching, rolling ship will be the same, and will therefore have much the same effect on the SQS-26 Sonar operators. High sea states also increase background noise on sonar and hence decrease the signal-to-noise ratio making target detection and tracking very difficult. The problems of round-the-clock operation and other normal shipboard routines and conditions should have the same effect on the vigilance and fatigue of SQS-26 operators as with other sonar systems.

(U) The low level lighting required in the sonar room is expected to be the same, as are interruptions by visitors and ship calls. These typical shipboard conditions are standard operating conditions to which all sonar personnel must adjust.

(U) Space limitations causes crowding during Condition One watches. Movement and communication is impeded and distraction and error is possible. However, this crowding is similar to conditions aboard most ships.

(U) There are certain non-environmental conditions that adversely affect operation and are due to the design of the SQS-26 Sonar in three areas: (1) communications, (2) classification of targets, and (3) equipment operation.

(U) No specific provision has been made for communication between the SQS-26 operators or between the supervisor and the three operators during search and track operations. When the operators are listening to echo returns via their headsets, other communication is limited. This condition is particularly acute for the B-Scan operator, who receives a binaural audio signal and must listen for longer periods than either the A-Scan or tracking operators. The method adopted by the operators and supervisors to overcome this difficulty with hand signals and other means will require practice for coordinating the operation of the consoles.

(U) This problem is compounded by the number of times coordination between consoles is necessary to complete an operation. The echo trap sequence is one example, and the use of the ON-TARGET button is another. The allocation of functions that affect the entire system to only one of the three consoles also creates a minor communication problem when a condition must be changed.

(U) It may prove to be difficult to classify echoes detected with SQS-26 Sonar due to the expected adverse signal-to-noise ratios. Echos may appear on the CP portion of the A-Scan display that cannot be verified on the CW portion or on the GI or SSI displays because the processing of CP echoes is different in order to enhance detection. Echoes which can be observed on a CP channel may be completely obscured by noise on the CW channel and on the SSI. When the echo is detected in CW, it should also be observable on the SSI and GI

display for verification and classification. Echoes detected in the B-Scan display can be verified on the PPI but no such additional aid is provided for A-Scan echoes. The low frequencies used in SQS-26 Sonar appear to limit the usual audio classification cues heard on other active sonars. This problem has been reported by operators in the fleet, but its extent and seriousness is unknown. Greater experience with the SQS-26 system in the at-sea environment under known conditions may reveal techniques that would alleviate this problem.

(U) Another adverse condition is created when the modes or settings must be changed during operation of the equipment. The knob positions, switch positions, and switches that are OFF are not lighted and cannot be seen in the darkened sonar room. To change modes or make other equipment settings, the operator must proceed by feel and by his memory for switch locations on the panel. He must then activate the change and observe the result, rather than being able to make a positive desired setting without fail on the first trial.

(U) The lack of light coding on indicator lamps is another awkward condition. Imaginative use of red, green, yellow, and amber colored lamps would allow the operator to determine, at a glance, which conditions were normal, which required attention and which were emergency malfunctions.

(U) The placement of the DIMUS recorder inside its cabinet forces the observer to stoop to read the chart. Since the chart is read frequently and no seat is provided, this design may cause improper attention to the display or undue fatigue.

(U) These adverse conditions affect all modes of operation, and are partially inherent in the current system design. Training should be provided to permit operators to adjust to these situations. Shore-based trainers should duplicate these conditions for realistic effects.

CONTINGENCIES

(U) Contingencies are considered those events which require the operator to take non-normal, backup or emergency action. In the SQS-26BX Sonar System, contingencies will be limited to malfunctions of the equipment and perhaps unexpected events. Operator action in the case of equipment malfunction will depend on the nature of the malfunction and the urgency of the need for sonar information. Due to the limited experience with the equipment and the high reliability, specific contingencies or backup actions are not known. When required, alternate modes, channels or other equipment changes can be used and the operator will need to continue to perform as best he can with the degraded equipment. Until data on specific contingencies and appropriate operator action is known, it is considered inadvisable to attempt to predict contingencies in detail.

SECTION III

SQS-26 SONAR OPERATOR TASK ANALYSIS

ACTIVITIES

(U) A task analysis of the activities of the three operators and sonar supervisor of the SQS-26 Sonar System was conducted as recommended in NAVTRADEVCEN Technical Report 1218-4. Although the format and suggestions were followed where applicable, a number of variations were found to be necessary because of the unique characteristics of the SQS-26 system.

SYSTEM ANALYSIS

(U) As recommended in Report 1218-4, the operation of the SQS-26 was organized into identifiable blocks or phases of activity. Each block was identified at a specific beginning and ending point for convenience, and was given a characteristic name based on normal sonar useage. The block name and indicated activity is not necessarily exclusive. The major blocks are shown in the system block analysis in table 3. The numbers and names of the blocks in table 3 were kept consistent throughout the remainder of the analysis, and proved to be quite satisfactory in communicating and conducting interviews with operating personnel. The activities of the four persons in each block of activity were summarized, and are shown in table 4. This table shows the general nature of activity for each operator, and whether he is actively engaged in the activity or is idle during the block.

(U) Each block shown in table 3 was then analyzed in greater detail. This second level of detail provided satisfactory understanding for block 1, but the detail was insufficient to analyze the remaining blocks. Consequently, a third level of detail of operator activity was made of those parts of blocks 2 through 7 for which information was available. This detail is shown in Appendix B. Since information on the conduct of underwater communication, block 8, was not available to the analyst, it has been omitted. Block 8 is not related to the ASW problem, so this omission is not critical. As recommended in NAVTRADEVCEN 1218-4, operator activity was identified to the level necessary to determine and judge the following objectives:

1. Identify the task and determine which person or position performs each task.

2. Determine typical total times for blocks (or tasks).

3. Determine typical task duration and coordination requirements.

4. Determine any adverse conditions that affect, in the same manner, all tasks being performed simultaneously.

Table 3. System Block Analysis

Block Number	Block Name	Remarks
1	Compute settings and predict performance	First action required when watch begins. May be repeated one or more times during watch period.
2	Setup and checkout of equipment	Performed at beginning of watch and may be repeated during watch. May be omitted if watch continues previous watch activity.
3	Conduct search (Search phase)	Normal predominant activity on watch. Ends when consistent echo is detected.
4	Contact Phase	Follows block 3. Begins when consistent echo is observed, or definite audio signal is heard. Ends when ON-target button is pressed or echo is classified as definite NON-SUB, and block 3 activity is resumed.
5	Track target (Track phase)	Begins when ON-target button is pressed. Ends when FCS AIDED TRACK is accepted at SONAR.
6	Conduct attack (Attack phase)	Begins when SONAR has accepted AIDED TRACK, ends when target is lost or destroyed.
7	Conduct lost target search	Begins when successive echos fail to appear after contact has been established.
8	Conduct underwater communications	Special condition of use not related to ASW. Omit from study.

[illegible] Probe [illegible] Select [illegible] A Check Operation of A-Scan Equipment and depressed Channel	Conduct BB Search or [illegible] Search
Check Oper[illegible] B-Scan Equip[illegible] [illegible] Surface [illegible] Channel	Co[illegible] Search or [illegible] Scan [illegible]

...m Block and Operator Activity

BLOCK 4 – Investigate Contact	BLOCK 5 Track Targets	BLOCK 6 Conduct Attack	BLOCK 7 Conduct "Lost Target" Search	BLOCK 8 Communications
...upervise and ...ake Classifi- ...ation Decisions ...serve Passive ...corder	Supervise and Make Classifi- cation Decisions	Detect Torpedo and Bearing Signals on Passive Recorder Communicate with BRIDGE, CIC and FCS on Target information. Sonar Quality, Course and Speed of Own Ship	Supervise and Help Operator to Recover Target	Undefined
...serve and ...ack Echo on ...Scan Analyze ...dio indications	Monitor Tracking and Continue Search for Other Targets (Listen to Audio on surface duct channel)	Continue Search for Other Targets	Conduct Lost Target Search BB or CZ	Undefined
...serve and ...ack Echo on ...Scan and PPI ...relate PPI ... B-Scan Indi- ...tions ...alyze Audio ...ications	Monitor Tracking and Continue Search for Other Targets (Listen to Audio on depressed channel)	Continue Search for Other Targets	Conduct Lost Target Search ODT or RDT	Undefined
...ack and Investi- ...e Echo on SSI ... GI in Omni- ...annel ...ack and Investi- ...e Echo on SSI, ...nd GI in Uni ...annel	Track Target on SSI and Note GI Indications	Maintain Cursor position on SSI	Assist in Lost Target Search all modes	Undefined
Energize and check out equipment	Switch to Sonar and Determine Target Course and Speed	Operation Mk 53 position and update course and speed	Maintain Mk 53 in Position Keep Mode	Undefined

(U) It was found that the third level of detail shown in Appendix B is sufficient for making these determinations and judgments. However, to verify that still finer detail would not reveal additional pertinent information, block 3 was subjected to a fourth level of detail analysis. This fourth level of detail is shown in Appendix C. This level shows each button, switch, and knob activated in sequence by the operator. Since this type of information is time consuming to collect, and was found to provide little help in making decisions and recommendations, the fourth level of detail was not determined for the remaining blocks.

(U) The operational tasks, procedures, decisions, and communication links shown in detail in Appendix B were first obtained by studying the operation manuals on the SQS-26BX system and other reports and OP's available to the analyst.

(U) To verify that the procedures and the allocation of functions conformed to Navy doctrine and practice, the tasks shown in Appendix B were discussed in detail with cognizant officers and sonar technicians at the Fleet ASW school in San Diego. This was done by reviewing a rough draft of Appendix B on an item-by-item basis using interview technique. Tasks, procedures, and details that were questionable were further analyzed. With no established operating procedures or doctrine, the best procedures to follow were mainly a matter of expert opinion. The qualified operators and technicians that were interviewed agreed that a number of techniques could be used satisfactorily. Therefore, for the purpose of this study, the decision was made to select one reasonable procedure as standard, even though complete agreement was not reached.

(U) The Sonar Officer and two sonar technicians from USS Fox (DLG 33) were then interviewed in a similar manner with a revised draft of the task outline. Personnel from the USS Fox were chosen because it was the one ship readily available with the SQS-26BX system installed. All comments and suggestions made by USS Fox personnel were given special consideration. Their comments regarding procedures in the operator's manual were particularly significant, since in some cases different procedures were used.

(U) The sonar officer and Chief Sonar Technician from the USS Wainwright were also interviewed regarding procedures. They indicated that they attempted to follow the procedures in the manual where possible but deviated from them for better operation. They were in the process of developing better procedures through their at-sea experiences.

(U) Consideration was also given to including procedures and tasks required when malfunctions occur. It was found that malfunction procedures were even more tentative than normal procedures. Results to date at sea with the SQS-26BX model were so limited that these tentative procedures had not been verified. The high reliability of the BX model and the limited operational experience did not permit opportunities to try out or practice these malfunction procedures. When the system did not function as expected, immediate maintenance checks were initiated to identify and correct the problem rather than attempting to continue operation in a degraded condition. This approach is appropriate at this stage of system development but obviously will not be used in an operational attack. Training in malfunction procedures, however, can be provided by including malfunction conditions in the trainer even though specific procedures cannot be defined at this time.

(U) The task list shown in Appendix B was prepared as a plausible standard procedure list. The main task list entries were based on at-sea experiences while the alternate procedures were based on recommendations in the operator's manual. Since actual at-sea operating procedures vary between ships, neither the main task list nor the alternate task list should be interpreted as definitive or doctrinal. Instead, these should be regarded merely as approximations of task orders and procedures until more experience can be gained with equipment at sea.

THE OPERATIONAL SEQUENCE DIAGRAM

(U) After the detail task analysis was outlined as shown in table 4, an operational sequence diagram was prepared. This diagram, shown in Appendix D, essentially follows the approach suggested in NAVTRADEVCEN 1218-4. The diagram uses the same order and numbering system as the detail tasks and subtasks in Appendix B. It further indicates which of the three operators (or supervisor) performs each of the steps, and shows the number of intercommunication links between operators. Symbolic coding is used to help identify the type of activity in each task. The number of symbols was limited for simplicity and ease of use. Each task listed in Appendix B is shown as a numbered symbol to correspond with the task number. By using Appendix B and Appendix D together, a very good understanding of the sequence of operator tasks and procedures for the SQS-26 system can be obtained.

TIMING FACTORS IN SQS-26 OPERATION

(U) As suggested in NAVTRADEVCEN 1218-4, an attempt was made to determine the time required for operators to complete the tasks and blocks in table 4. In the process of analysis, system cycle time was found to be much more significant than operator time. The time required for the transmitted sound pulse to reach the range of interest and return is the prime factor in operator time and block times.

(U) The number of cycles or pings was next considered in terms of operator performance. A highly skilled operator should be able to detect and classify a target with fewer pings than a novice. Under poor environmental conditions, a larger number of pings and shorter ranges will be necessary for detection even with highly skilled operators. Similarly, the time required to classify a contact is also dependent upon sonar conditions, although a highly skilled operator will usually be able to classify a contact on fewer pings than a novice.

(U) The data in this report attempts to show a typical time for each system block, assuming sonar conditions are good and the operator highly skilled. These figures require ideal conditions that are rarely encountered in practice. Similarly, a typical range for each mode was assumed, and the time was computed for sound to travel to this range and return as an echo. With these assumptions, the data summarized in table 5 can be considered as typical minimum times for sonar operators for each system block. The detail task-by-task time used to compute system block times is shown in Appendix E.

FUNCTIONAL ANALYSIS OF TASKS

(U) The level of task detail shown in Appendix B permits each operator action or task to be analyzed, in terms of its probable requirement for training. This analysis involves considerable judgment, and was based both on training experience and on logical assumptions as suggested in NAVTRADEVCEN 1218-4 with variations. A preliminary study of the tasks indicated that many were simple procedures and would need little training. Therefore, a columnar table was used for this analysis rather than separate detailed forms for each task. In general, the analysis considers each task listed in Appendix B and assigns a code to each task for each of the following parameters:

1. Type of activity
2. Type of sequence
3. Criticality
4. Coordination with others
5. Specialized behavior involved
6. Difficulty of performance
7. Dynamic condition involved

(U) Analyzing each task in terms of these seven parameters it was felt would provide sufficient information to make the necessary judgments regarding the need for training, the type of training, the approximate extent of the training period, and the level of training equipment complexity needed to train operators to perform each ask.

(U) Gradations within each parameter were kept very broad for this preliminary analysis. This was done to identify significant tasks first, and to eliminate the great number of tasks for which no training is necessary beyond an orientation period. The description of the columns and gradings used in this analysis are as follows:

1. Task Code Number. This number is the task number shown in Appendix B.

2. Operator. Primary operator performing the task:

   a. S - Supervisor
   b. A - A-Scan Console Operator
   c. B - B-Scan Console Operator
   d. T - Tracking Console Operator
   e. O - Other operator, not in sonar station

Table 5. Estimate of System Block Times
(Per NAVTRADEVCEN 1218-4)

Block 1 - 10 minutes to complete

Block 2 - 10 minutes to complete

Block 3 - Continuous operation throughout watch, interrupted only by going to block 4 activity

Blocks 4 through 7 depend upon the specific mode of operation.

	CZ Mode	BB Mode	ODT Mode	RDT Mode	DIMUS
Block 4	209 sec.	230 sec.	81 sec.	87 sec.	25 sec.
Block 5	110 sec.	176 sec.	56 sec.	57 sec.	--
Block 6	--	--	203 sec.	203 sec.	--
Block 7 (Regain Contact)	166 sec.	184 sec.	47 sec.	47 sec.	--

(Target detection to verification of computed course and speed). Blocks 4 through 6 combined.

			ODT Mode	RDT Mode
Minimum Attack Time	--	--	340 sec.	347 sec.

3. Type of Activity

a. Procedure Following Task. The task follows an established procedure and is performed on cue.

b. Monitoring Task. The task consists of sensing, discriminating, and interpreting a signal or signals that are not always present.

c. Perceptual Motor Task. A task involving coordinated sensory and motor activity including continuous and discontinuous action (i.e., tracking and positioning skills).

d. Communication Task. Verbal transmission of information or orders by intercom, phone, or direct voice.

e. Decision-Making Task. Selection of a choice of action from among alternatives, including problem solving when solutions are not automatic.

4. Sequence

a. F - Fixed sequence of activity which follows the same routine each time performed.

b. V - Variable sequence activity which does not follow a set routine, but is adjusted to the prevailing conditions and requires nonrote performance.

5. Criticality

a. 0 - Activity not essential for completing mission

b. 1 - Task is necessary to complete mission, but its performance is either simple, can be performed within a broad tolerance, or without accuracy or time pressure.

c. 2 - Task is essential to complete mission and must be performed timely, highly accurately, or has other major significance to mission success.

6. Coordination

a. 1 - Performed completely by one operator

b. 2 - Coordination between two operators is required

c. 3 - Coordination among three or more operators is required.

7. Specialized Behavior (S. B.). Operator behavior characteristics in terms of previous experience, skill, or training:

a. 0 - Not related, not pertinent, or readily perceived

b. 1 - Readily learned in orientation period (less than one day)

c. 2 - Short period of training and practice probably necessary (less than one week)

d. 3 - Extensive experience and practice with a wide variety of stimulus or problem conditions is required for effective performance.

8. Difficulty of Performance

a. 0 - Not difficult

b. 1 - Difficult

c. 2 - Very difficult

9. Dynamic Condition

a. S - Static. Simple on/off light or digital readout-type displays: simple pushbutton or knob adjustment-type controls

b. D - Dynamic. Dynamic displays or control acts are involved such as interruption of PPI display, tracking or positioning cursor on moving display, etc.

(U) The results of this analysis as described above for each task listed in Appendix B is shown in Appendix F.

SECTION IV

ASSESSMENT OF OPERATOR TASKS IN TERMS OF DIFFICULTY AND CRITICALITY TO SUCCESSFUL TEAM PERFORMANCE

INTRODUCTION

(U) The task analysis of operator activity in the SQS-26BX Sonar System in Appendix B provides a detail breakdown of tasks required to operate the equipment. The functional analysis of these operator tasks for their implications for training is shown in tabular form in Appendix F. This functional analysis provides the basis for the decisions regarding the training of operators.

(U) Of particular importance are the tasks which are judged as difficult to perform and critical for successful team performance. Training for these tasks must be provided for effective operation of the system because each of these tasks tend to be unique. The difficulty of performance and the fact that these tasks are unique on the SQS-26 are the primary indicators that specific training is required for effective operation.

(U) An analysis of the breakdown in Appendix F shows that certain monitoring tasks, some perceptual motor tasks, and selected decisions fall into the critical, difficult-to-perform, and unique-to-the-system category. All tasks included in Appendix F were classed as critical for operation of the system with the following judged to be also significant due to importance, accuracy, or affect on other personnel.

DIFFICULT AND CRITICAL MONITORING TASKS

(U) Monitoring tasks in this report are those tasks which involve the sensing and interpretation of visual and audio displays on the operator console. Difficult monitoring behavior is required in four groups of tasks.

Search

(U) As in other sonar systems, the most frequent behavior is the continuous surveillance of the display during search. This behavior is critical since it precedes all ASW activity. A target cannot be tracked and attacked until it has been detected. This behavior is difficult because constant attention for long watch periods is required. It is also difficult because many false contacts are expected and good contacts are not always consistent.

(U) When the system has been well maintained and is operating at peak performance, the discrimination between signal and noise is readily observed. This fact was verified by operating personnel on the USS Wainwright and by investigators from USNUSL. But when the system is not maintained at peak performance, the signal discrimination will be progressively more difficult as the performance of the system is degraded.

(U) The false contact ratio is due to the nature of the ocean environment. Many objects in the ocean will reflect sound and appear as echos. The nature of the sound transmission paths will mask or enhance echos from these

objects as well as echos from actual submarines. The result is the appearance of multiple signals on the displays on a given ping return but few consistent echos over a series of returns.

(U) To make a detection, the operator must observe the display of several returns and note which echoes correlate from ping to ping. An echo which appears consistently on successive returns, but not necessarily on every return, on the SQS-26, is caused by an object in the water and is a contact. The interpretation of echoes and contacts will be difficult at times due to the number of echoes and the fact that some are marginally detectable. Further analysis of echoes and contacts is part of the classification procedure which culminates in a decision to call a "Sonar Alarm" and signal the ON TARGET condition discussed later in this section.

Echo Correlation

(U) When an echo has appeared consistently on several returns, it can be correlated with previous returns on the A-Scan and B-Scan displays. These displays show a 6-ping and 3-ping history of echoes respectively.

(U) The B-Scan operator must also integrate, visually, the echo on the B-Scan display with the echo on the PPI display. If the echo appears on both displays, the B-Scan operator can position the cursor accurately in range on the B-Scan display, and in bearing on the PPI. Successive returns can then be observed for correlation and classification. Some difficulty is expected in integrating the echoes on these displays since the variability of echoes is apparent on both displays and the relative movement of target and own ship prevents exact correlation.

Multiple Targets

(U) After a target is observed and is being tracked on the SSI, the operators should be alert for additional targets. The A-Scan and B-Scan operators should monitor their respective displays even though the tracking console operator has control of the sector center bearing.

(U) If suspicious echoes are detected, they must be analyzed carefully by these two operators without help from the SSI or GI displays. If one of the operators detects what appears to be a contact and the SSI and GI displays are switched to this contact for verification, the tracking of the first target is interrupted. In the process of analyzing the new target, the first target may escape.

(U) The two-target problem will be difficult to coordinate to prevent the first target from escaping while checking on the second. Effective coordination will be required and a well practiced team effort will be necessary for effective operation, especially with intermittent data.

Lost Target

(U) When a target can no longer be detected on the displays after having been classified, a Lost Target Search is initiated. It can be generally assumed

that the target is taking evasive action to inhibit detection and is maneuvering to confuse the sonar. In any event, lost target search can be expected to be difficult, critical, and urgent for team and mission success.

DIFFICULT AND CRITICAL PERCEPTUAL MOTOR TASKS

(U) The difficult tasks involving perceptual motor activity are limited to (a) positioning the B-Scan cursor on two displays simultaneously which ordinarily does not require a high degree of precision, and (b) positioning the cursor on the SSI.

(U) The placement of the cursor on the SSI is critical and must be as accurate as possible. The accuracy of this placement is the limit of accuracy for the remainder of the ASW system. Fortunately, this appears to be relatively easy to do after learning exactly where the cursor should be placed in relation to the echo. The manipulation of the joy-stick cursor control does not appear to be difficult. However, the high degree of accuracy required indicates that training and experience with low signal-to-noise ratios will be necessary. Of interest here is that the signal-to-noise ratio of CP signals on the A-Scan display is significantly better (by 12db) than on the SSI due to the methods of signal processing. This fact will permit some targets to be detected on the A-Scan which can not be seen or tracked on the SSI.

DIFFICULT AND CRITICAL DECISIONS

(U) The critical and difficult decisions required in the operation of the SQS-26 Sonar will be made by the sonar supervisor. As part of the sonar team, the A-Scan, B-Scan and Tracking Console operators will advise and recommend, but the actual decisions are expected to remain with the supervisor. The most difficult decisions appear to be as follows.

Selection of Mode

(U) The first decision is the selection or approval of the operational mode which is to be used and approval of the necessary switch settings to be used. Insertion of the test-set target and observation of noise and reverberation at maximum range-of-the-day will enable the supervisor to determine the operational capability of the system. A thorough knowledge of ocean characteristics and system capability and limitations is essential for making these decisions.

(U) A corollary to the determination of maximum ranges and probabilities to expect, is the decision for appropriate action in the case of malfunctioning equipment. If the system is not operating at peak performance, the supervisor must decide whether to continue operation at less than peak performance, to cease operation and repair or adjust the equipment, or to continue partial operation during maintenance. If the system can not be operated at full efficiency, the supervisor must recommend the best alternate action to the ships command. Operation in alternate and backup modes will be difficult, compared to normal operation and depending on the tactical orders, may be critical to the ships overall mission.

Identification of Contact

(U) Another difficult decision will involve the judgment required to identify a signal as a sonar contact and to begin tracking with the fire control system.

(U) The doctrine for calling a sonar alarm with the SQS-26 Sonar has yet to be fully formulated by the fleet. Until such time as the sonar alarm doctrine is established, the sonar crew must depend on personal judgment and general orders from the bridge. The difficulty lies in the frequency that sonar alarms may be called. For example, if a minimum number of echoes are seen on the displays, and these do not correlate, the first observation of a correlated echo would be justification for calling an alarm. But if ocean conditions are such that many echoes are seen and many correlate for several returns, the supervisor must decide if the alarm should be sounded for each one. The tentative classification of these contacts as possible targets is part of this decision which may increase its level of difficulty. It appears that the sonar supervisor may have to adjust his decision making rules and procedure in calling sonar alarms, to the oceanographic and equipment conditions prevailing at that time. These decisions are critical in that they must not overlook actual submarine targets that come within range of the sonar.

Acceptance of Aided Track

(U) A decision required of the sonar supervisor which may have a significant and critical effect on a successful ASW attack is whether to accept the aided track input from FCS. This decision may be difficult if the tracking is marginal. If tracking is smooth and steady, or if obviously erratic, the decision is easy. But marginal conditions may create a difficult decision because of the delay in the progress of the attack if the solution is not accepted. If accepted too readily the echo may be lost due to erratic tracking.

Signal Enhancement

(U) Under some conditions of operation, targets will be detected under marginal conditions. A decision will be required by the sonar supervisor or the tactical command whether to change the sonar transmission mode to enhance detection, or to maintain the current marginal settings and mode so the target will not be alerted.

(U) This tactical decision will depend on a recommendation from sonar on the probability of losing the target versus the probability of obtaining better tracking so the target cannot escape. How and when to modify the transmission and which course to steer may be a difficult and critical decision.

Multi Target Attack

(U) An important decision, which will be made at a higher command level than sonar supervisor, is the choice of target to attack when more than one target is observed. This decision must be based on many factors beyond the knowledge of the sonar supervisor, such as: which target constitutes the larger threat; the stage of the current attack; what weapons are available and other units available for support.

(U) *For the overall ships mission, this decision is critical and may also be* difficult to make. But for sonar, timely and accurate detection and accurate tracking of both targets is the main matter of importance.

Abandon Lost Target Search

(U) The decision to continue or abandon an unsuccessful lost contact search may be made elsewhere than in sonar. As a normal procedure, CIC will recommend search vectors and patterns based on their plots and tactical intelligence. CIC may also recommend when to abandon the search. The decision for sonar is to appraise their returns and make realistic reports on probability of detection to CIC.

DIFFICULT AND CRITICAL PROCEDURE-FOLLOWING TASKS

(U) For the purpose of this report, a task is classified as a procedure-following task, if the operator performs an action when ordered or when signaled to do so by a light, a change in a display or other cue. The resulting procedural action may follow a fixed sequence if always performed in the same way or a variable sequence if not identical from one performance to the next.

(U) The list of tasks shown in Appendix B and the analysis in Appendix F shows that approximately one-third of the tasks were deemed to be simple procedure-following tasks. All tasks were rated as critical (necessary to complete the mission) or were omitted. Most procedure-following tasks were judged to be not difficult except for the task of checking out equipment to determine normal or malfunctioning operation. This task was judged to be difficult. The difficulty lies in the need to analyze the displays when various settings are made on the equipment. The variety of indications which may be displayed will require interpretation to determine the extent of any abnormal function. If the equipment is not at peak performance, completion of the check-out procedure is expected to be difficult because the indications must be analyzed for the probable cause of malfunction. This probable cause should then be checked with other settings to minimize the effect of the malfunction.

(U) Each operator should be able to perform these preliminary operation troubleshooting tasks even though considerable judgement may be required.

(U) The complex and difficult procedure required of the Mk 53 operators to determine target course and speed is evident but is beyond the scope of this study. It is unlikely that the difficulty of operation of the Mk 53 on the SQS-26 equipped ships will be different than on SQS-23 equipped ships.

(U) The performance of other procedure-following tasks is expected to fall within the repertoire of new students. That is, each task probably can be performed after an initial orientation period. However, the total complexity of the procedures should not be overlooked. The variety of modes, intervals and blocks of activity indicate that each operator must know many combinations of tasks and procedures. The frequent coordination of effort between operators, as shown in the operational sequence diagram in Appendix D, indicates that these procedures can be critical for smooth performance. Thus, while individual tasks may be simple and easy to perform, the combination and coordination required indicates difficulty in learning to use and follow the appropriate procedures.

DIFFICULT AND CRITICAL COMMUNICATIONS

(U) Communication between operators or with other men on own ship will be as difficult as all communication in variable conditions. Although noise is not involved and communications phones and an intercom are provided, the procedures frequently are not followed and transmissions are misunderstood. Communication between operators and the supervisor must occur when the operators are listening to the audio signal which will cause some interference. In some situations, the communication will be critical for success of the mission.

SECTION V

INDIVIDUAL AND TEAM TRAINING REQUIREMENTS FOR SQS-26 OPERATORS

INTRODUCTION

(U) The number of unique, difficult and critical tasks described in the previous section of this report indicates that a comprehensive training program is required to enable new men to perform these tasks effectively. Training is necessary to familiarize the men and provide the basic skill in operating equipment and interpreting displays which are unique to the SQS-26 Sonar and different from any previous sonar displays. Based upon the task analysis and training analysis conducted during this study, individual and sonar team training for SQS-26 operator personnel is recommended. Periodic training of the sonar team with the remainder of the Own Ship ASW team is also recommended. However, no attempt was made to develop a specific training program in detail for SQS-26 operators. Such an effort was considered to be beyond the scope of this study. Rather, the comments and recommendations which follow indicate the type of subject matter and training experiences that should be included in a program of training for SQS-26 operators.

(U) Practice is required to develop the skill and to learn to perform the difficult tasks smoothly and efficiently. Since a large number of these unique and difficult tasks are critical for effective sonar operation, unless the operator is trained to a high level of skill, the system will not operate at its maximum capability.

(U) The number of tasks shown in Appendix B and the coordination among operators required as shown in the Operational Sequence Diagram in Appendix D indicates that a considerable amount of training will be required for men to learn these complex procedures. Even though each procedure is relatively easy to follow, as discussed in the previous section, the number of different tasks and the variations in the different modes of operation and stages of the search, track, and attack process indicates that extensive practice will be required to learn to perform the appropriate task skillfully at the appropriate time.

(U) The interpretation of displays and the classification of contacts is another task which will require training and practice. In some situations, contacts will be difficult to distinguish from noise. Under conditions of high sea state, high own-ship speed, or severe biological conditions, the background noise and reverberations are expected to severely limit the range. But with practice skilled operators will be able to function even under severe conditions, as demonstrated with previous sonars.

(U) A comprehensive training program must include a consideration of classroom instruction, practice with various types of training equipment and practice and experience with operational equipment in the operational environment. The following section directs attention to the areas of study recommended for classroom training, display interpretation, equipment operation training and team training. While this report points to the use of the SQS-26 Sonar System

trainer and the 14A2A ASW team trainer, it is not meant to imply that other techniques or trainers, including movies, tape systems and other training devices are not necessary or would not be beneificial. What is intended is an overview of the entire SQS-26 training requirement to identify those features which increase the effectiveness of training in a shorebased trainer.

(U) Similarly it is not implied that a shorebased trainer would eliminate the need for at-sea training with operational equipment in the operational environment. Rather this section should be viewed as an indication of how shorebased training of various types and at-sea experience can complement each other in the development of highly skilled operators of the SQS-26BX equipment.

TRAINING REQUIREMENTS

(U) An analysis of the tasks and performance requirements of SQS-26 operators indicate that a comprehensive training program is required. The following outline is recommended as the basis for a systematic and comprehensive program of instruction for SQS-26 operator personnel.

Prerequisite Classroom Knowledge

(U) 1. Orientation to Sonar. Discuss purpose and function of sonar in the Navy and ASW. Cover types of sonar, passive and active sonars, principles of operation and other background material for sonar operators.

(U) 2. Oceanology. The characteristics of the ocean have a much greater effect on the operation of the SQS-26 Sonar than on previous sonar systems. Therefore, students should have a thorough understanding of the ocean environment. This training should include characteristics of sound in sea water, effects of temperature on sound transmission, and effects of pressure and salinity. The cause and effect of various transmission lossses should be covered as well as the effect of bottom conditions, sea state, biologics, and wind. Charts of environmental conditions in various areas of the world should be presented and students trained to interpret the charts for specific localities.

(U) 3. Ships Equipment. Various items of ships equipment which the operator will use should be included in training. The function, accuracy and interpretation of data from equipment such as ships logs, anenometer, fathometer, pit log, etc., should be covered.

(U) 4. Bathythermograph. The bathythermal layer and use of the bathythermograph should be thoroughly covered in classroom training. The various types of equipment which are currently in use should be explained and shown to the trainees. A wide variety of realistic BT traces (copies of actual traces) should be provided and the trainee drilled in their interpretation. The effect of the BT layer on sound transmission, echo reception, range, and probabilities should be thoroughly covered in this training.

(U) 5. Check List Computations. The speed of sound and range computations required for setting up the equipment should be completely covered in the sonar training course. Students should be given realistic data and

drilled in completing the checklist and making the setting determinations and range predictions for this vital operation. All activity necessary to accomplish the block one tasks shown in Appendix B should be covered in the classroom.

(U) 6. Audio Training. At this time, training in audio interpretation cannot be recommended. Reports from USS Fox and USS Wainwright indicate that the audio signal is used only to verify the presence of a target and to improve bearing accuracy. Further interpretation of the audio signal for classification purposes was felt to be impractical if not impossible. On these two ships, audio was not used for classification. The audio interpretation on DIMUS is unknown at this time. One report indicated that audio is used only to verify the bearing shown on the display and another report indicated that machinery noises could be heard on close-in targets. The need for training in interpretation of audio signals in DIMUS is not known due to the limited use of DIMUS in the operational system.

(U) 7. In all sonar systems, the classification of detected contacts is critical. Frequently the combined efforts of Sonar, UB Plot and CIC is required. In the case of previous Sonar Systems, the operator analyzes the characteristics of the audio signal and video display for elusive and obscure clues and cues for indications that the contact is or is not a submarine. To provide training for this analysis, displays of the highest attainable fidelity are used. With the SQS-26 system, the classification of contacts is still somewhat clouded. Some reports have indicated that the system is sufficiently advanced to eliminate many of the non-sub contacts, and thus persistent signals will only occur from definite objects in the water. In addition, the very low frequency audio used and the nature of the processed signal on the display eliminates many of the fine discriminations which are available on previous sonars. Classification is thus limited to verifying that successive echoes correlate on the display, that doppler is present and that the target can be tracked. These indications are readily perceived so classification may no longer be a significant training problem. If these reports are verified with additional fleet experience, the need for classification training will be greatly simplified. However, if experience shows that classification continues to be difficult, training will of course continue to be necessary. In this case, specific training methods for classification training with high fidelity displays, such as those obtained with tape techniques, will be required.

System Knowledge

(U) 1. SQS-26 System Design. Operators should be taught the overall system configuration and principles of operation of the SQS-26 system. System knowledge should include principles of operation of the transmitter and receiver, information flow in the system, principles of operation of the processor, and design and location of the equipment. This part of the training course could also serve as an introduction to system maintenance which is not considered in this study.

(U) 2. SQS-26 Modes and Operation. Students should receive thorough training in the various modes of operation of the SQS-26 Sonar. This part of the course should include reasons for using each mode and the resulting ranges, limitations, and conditions. The operation of the equipment in the various search, track, and aided-track intervals should be thoroughly mastered by the student.

(U) 3. Orientation to the Consoles. As part of the system knowledge, the students should become completely familiar with all operator consoles. This can be achieved partly by studying pictures and diagrams in the Operator manuals. The function of each control and display must be memorized and learned thoroughly. Some of this knowledge can be acquired from manuals, but it can only be completed on actual equipment. This may be the maintenance training equipment, which is actual operational hardware, or it can be simulated hardware High fidelity simulated hardware for operator training has the advantage of not interfering with maintenance training classes. It is proposed that simulated hardware in a separate facility be provided rather than using the maintenance trainer for this type of training.

(U) 4. Orientation to ASW. As a follow-on to sonar orientation in the classroom, operators should be provided with orientation to other shipboard ASW equipment. If not provided previously, it must be done when the man is assigned aboard ship. The operators should know what happens to data which is transmitted both verbally and electrically from sonar. For example, the operators should be familiarized with the display on the Mk 53 plotter, and the Mk 53 operators task. This procedure will be effective in fostering cooperation between the sonar and Mk 53 operators. Similarly, the operator should be briefed on the CIC operation which uses long range sonar information. All of this information and coordination should be presented in the context of ASW. All operators should thoroughly understand the impact of sonar on the ASW mission, and some of the tactics used in ASW. Of particular importance is the effect of sonar on tactics. Operators should be aware of the alerting nature of changed sonar transmissions and the ability of submarine commanders to draw conclusions from these changes.

Basic SQS-26 Operator Training

(U) After the thorough classroom training and orientation, the student needs to learn the specific operation of the equipment. Each operator should learn the operation of all consoles to provide flexibility in scheduling and assignment of personnel on the watch.

(U) 1. Equipment Settings. Each operator should practice making the required checklist entries and computations to determine the equipment settings on each console. These computations and settings should be carefully checked by the instructor for accuracy and the student operator should be shown the effect of improper settings on equipment operation. The student should practice determining how target echos can be enhanced and be instructed on the equipment changes which will enhance echo detection.

(U) 2. Display Interpretation. Of major concern in SQS-26 operation is the proper interpretation of displayed data and signals on the A-Scan, B-Scan and PPI displays. Since the visual display is the primary detection method, operators should be well versed in a wide variety of visual patterns, signals and noise conditions so they can interpret the displays correctly. Considerable practice may be necessary to enable students to differentiate between submarine and non-submarine echos for classification. Under certain conditions the detection of echos masked by background noise will also be a problem requiring training and practice. These conditions should be presented in the training environment for practice preferably with high fidelity video displays.

(U) 3. Perceptual Motor Skill Training. A limited amount of time will be required to teach students to use and position the cursor on each console effectively. The importance of accuracy must be stressed and practice should be continued with a variety of realistic signal/noise ratios until the trainee demonstrates that he can accurately position the cursor on each console.

(U) 4. Operational Procedures. Each student should be given practice on following proper procedures using each console. Coordination between the operators can only proceed smoothly when each operator is thoroughly familiar with the operation of each console as follows:

a. A-Scan Operator. Mode selection procedure and enhancement of A-Scan Display.

b. B-Scan Operator. Surface channel transmission procedure and B-Scan display enhancement.

c. Tracking Console Operator. Graphic Display operation and positioning of the cursor on the SSI accurately.

d. DIMUS display interpretation.

Sonar Team Training

(C) Smooth operation of the SQS-26 Sonar System requires coordination among the four men on the sonar team. These four men will require training to work together as a team, to coordinate their actions and to learn effective communication techniques. Team training problems should be conducted for the following groups of operators:

1. A-Scan Operator and Tracking Console Operator

2. B-Scan Operator and Tracking Console Operator

3. A-Scan Operator, Tracking Console Operator, and CIC Plotter (for targets beyond 40,000 yards).

4. B-Scan Operator, Tracking Console Operator and Mk 53 Operator (for targets within 40,000 yards).

5. A-Scan Operator, Tracking Console Operator, B-Scan Operator, and Supervisor when the same target is detectable in both channels.

6. All operators when two targets are detected.

7. Lost-Target training with all above combinations.

(U) It is anticipated that this type of team training can be conducted adequately with an independent SQS-26BX Trainer. Communications and information can be transmitted to the instructor in lieu of transmission to actual CIC and Mk 53 Plotter operators. Position keeping data from the Mk 53 plotter can be simulated by the computer, under control of the instructor, since the only training desired is coordination of the sonar team.

ASW Team Training

(C) When the sonar team is successful in detecting a possible hostile submarine target, the ships ASW team is alerted to prepare for and conduct an attack. Total ASW team training is required so that the attack may proceed quickly and effectively. This training can be provided in a shorebased trainer where the entire problem can be controlled. The types of problem that should be generated for training, with applicable coordination and communication include the following:

1. Detect and track targets in CZ mode in sonar, plot target in CIC and vector an attacking aircraft, helicopter, or surface ship to datum. Instructor will control supporting unit per instructions from CIC Evaluator.

2. Same as (1) above with targets detected in BB mode at a range beyond 40K yard.

3. Same as (1) above with target detected in BB mode at a range between 20K and 40K yards and plotted on Mk 53. In this case, support unit will perform localization procedures, since sonar BB range and bearing will be inaccurate.

4. Detect target in BB mode at 20K plus yards; close to approximately 20K yards; detect target in ODT portion of BB/ODT; switch to RDT and vector aircraft and/or support unit to datum. If aircraft is vectored, complete the attack without localization procedure.

5. Detect target in ODT mode, close to within 10,000 yards, solve for course and speed and attack with ASROC weapon.

6. Same as (5) but continue closing to within 1000 yards of the target for attack with over-the-side weapons.

7. Detect target in CZ mode; close range into BB mode and then into ODT mode; continue closing to ASROC range for attack. (Own ship completes attack alone.)

8. Detect two targets; one in CZ or BB, the second in ODT. Maintain track on both. Vector aircraft to long-range target; close and attack with ASROC on short-range target.

9. Detection of multiple targets in ODT mode and attack each with ASROC.

10. Detect and track target in CZ and or BB mode; lose contact and continue search until contact is regained.

11. Detect and track target in ODT mode; lose contact; conduct lost contact search and regain contact.

12. Detect target, lose target, and fail to regain contact.

(U) These training problems can be conducted with the proposed SQS-26 trainer in joint operation with the 14A2A Trainer.

Complex ASW Team Training (with 14A2 Trainer)

(C) The above problems are typical of ASW exercises which may be used in a 14A2A/SQS-26 union trainer. More complex problems are also recommended to give the team experience and confidence with more difficult problems. Two examples of complex problems follow:

1. Two ship SAU group is formed to investigate reported contact at a distance of 40 miles. First echo is detected at 78,000 yards in CZ mode. Immediately a second echo is detected at 30K yards at 40° bearing from CZ sector center. Both echos are tracked and closed for 5 minutes when second echo is lost. A third echo appears, 10° off the bearing of the first, at a range of 18,000 yards and then two additional echos are observed on bearing of original target at 25K yards. Own Ship receives radio message that first echo is positively identified as a hostile submarine. Support unit reports positive identification of echo #2 as a submarine and Own Ship gets a closing range rate on the echos at 18K and 25K yards. Own Ship closes to ASROC range on the 18K yard target, but the first ASROC malfunctions. Problem continues in similar manner until all targets are destroyed or Own Ship is sunk.

2. Two ship SAU group is formed as advance-point screen for convoy. Poor water conditions limit sonar range to 12K yards. Two targets are detected at 10K yards at bearing of 60° and 300°. OTC directs Own Ship to attack target at 300° and dispatches support ship toward 60° target. Own Ship with SQS-26 Sonar is ordered to maintain contact with both targets. As range closes to 8000 yards, target divides into two with enemy countermeasures (noise spoke). Both targets now use evasive tactics.

REFRESHER TRAINING

(U) It is anticipated that few trainees will be able to proceed completely through the entire sequence of problems, as outlined above, in a continuous period. Rather, the more complex problems suggested will more likely be conducted after the new trainee has been assigned to a ship and the entire ASW crew from own-ship returns for refresher training. The frequent turnover of personnel on board ship indicates that on each return to the trainer, additional men will be new to the ASW problem. The sonar team as with other teams will have men at various levels of skill in any one exercise. This fact must be considered and accommodated in various ASW training exercises. Refresher training with actual teams will enable all members to practice together and perform their assigned tasks in the context of realistically simulated problems. A variety of exercises in the shorebased trainer will enable the less skilled members to increase their skill on simple problems and the more experienced men to practice their performance on advanced complex problems.

MALFUNCTION TRAINING

(U) The USS Wainwright reported that the SQS-26BX Sonar System is a highly reliable piece of equipment. When maintained at peak performance, which is

difficult to achieve, the system rarely malfunctioned or overheated. On other ships with less skilled maintenance personnel the experience may be different and malfunctions may reasonably be expected to occur during operation. It is further anticipated that some of these malfunctions will require a change in operational procedure and others will cause difficulty for the operators. Training with the equipment in malfunction conditions should be provided so operators learn to function under these conditions. The types of malfunctions which should be provided include display degradation due to system adjustment problems, partial failure of components or channels and total failure of complete units such as the B-Scan display, the PPI, or the coded-pulse or continuous-wave sections of the A-Scan display.

SECTION VI

LEVELS OF SIMULATION

GENERAL CONSIDERATIONS

(U) The following discussion of levels of simulation complexity which could be added to the 14A2A is a result of the analysis of operator tasks and activity on SQS-26 ships in ASW problems.

(U) Each level described shows a possible way that the SQS-26BX Sonar could be added to the 14A2A Trainer or how the 14A2A Trainer could be expanded to provide better ASW team training. The prime consideration in selecting and analyzing these levels is the effect on the trainee. It is assumed in the analysis that the signals provided would be as realistic as commensurate with the level of simulation described.

(U) The complexity of providing signals and interfacing with other parts of the trainer is not considered. Also not considered is whether the equipment and signals should be completely simulated or whether operational equipment should be used and then stimulated with simulated signals. The cost implication of each level was considered only after the training effect of the level had been identified and described. The levels of simulation considered are described as follows. The cost effects are shown in figure 13.

LEVEL 1-INSTRUCTOR INPUT IN PLACE OF SONAR

(U) This is the simplest level of simulation possible in that it provides no actual input by sonar personnel to the problem at all. An instructor would provide an electrical input in range and bearing to the Mk 53 computer and would call out range and bearing verbally over the 29MC and 61JS circuits. This level of simulation could provide a basic type of training to fire control and CIC personnel but would eliminate the sonar team entirely.

(U) Since the sonarmen are essential members of the own ship's ASW team, they should be included for adequate ASW team training. This is particularly important because the accuracy of performance and smooth flow of the problem is directly dependent on the performance of the sonar crew. Instructor input would not provide adequate training for essential members of the ASW team. This level is therefore not recommended.

LEVEL 2-SQS-26 TRACKING CONSOLE SIMULATION ONLY

(U) The Tracking Console Operator at the Tracking Console performs the last sonar operation prior to the transmission and dissemination of sonar data throughout the ship. With this level of simulation, the Tracking Console Operator could position the cursor on the SSI, generate data for fire control, and verbally call out range and bearing on the 29MC and 61JS circuits. The trainer would generate signals only for the SSI and GI and vary them only as necessary for realism on these two displays.

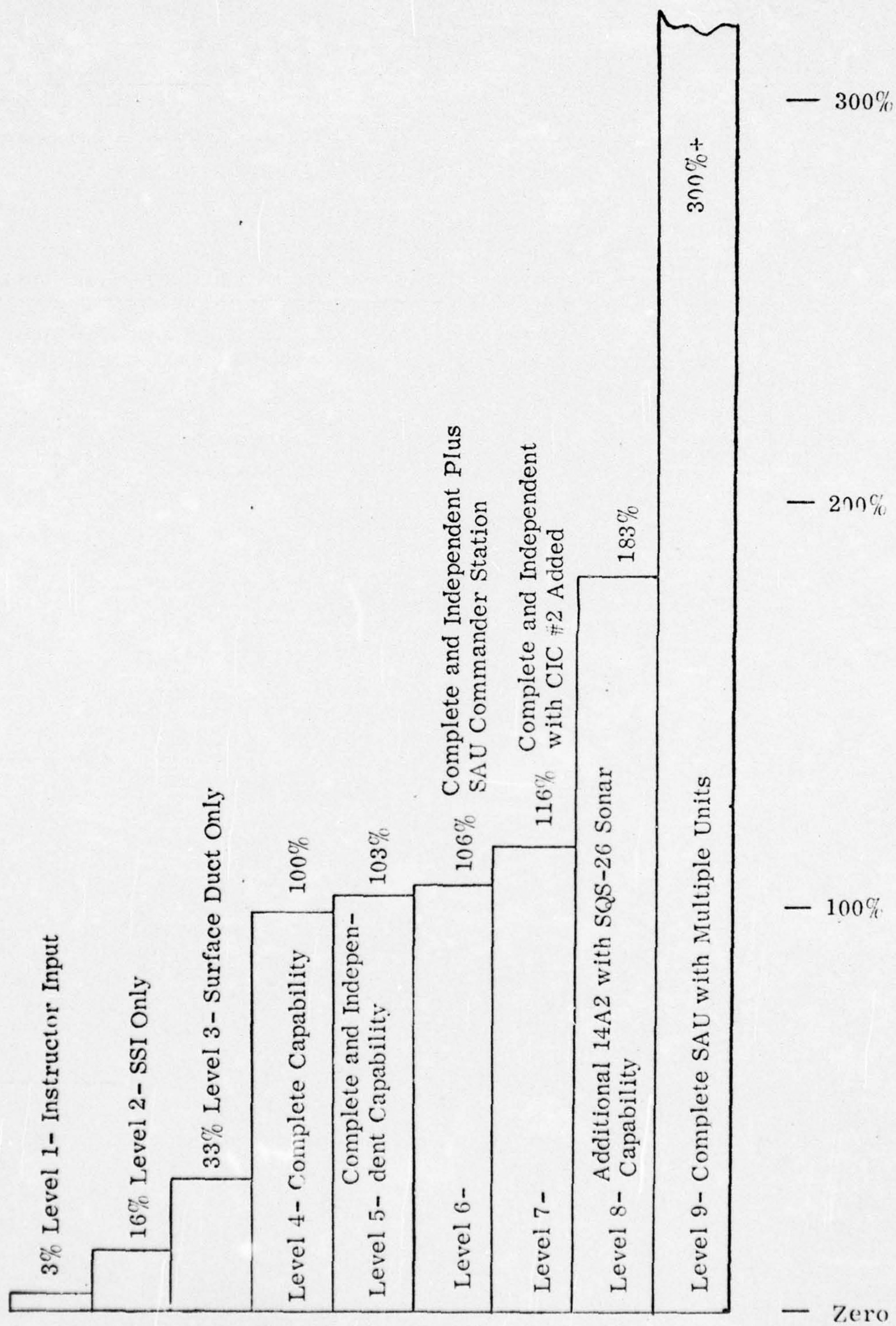


Figure 13. Comparative Costs of Levels of Simulation

(U) With this level of simulation, the problem would begin when the target appeared on the SSI. Immediately after the target appeared and was centered on the SSI, the operator could signal ON TARGET, even though this is normally done by the A-Scan or B-Scan Operators. As each successive return appeared on the SSI, the operator would position the cursor, press the NDT pushbutton, and announce the range and bearing as shown on the digital display. The team members in UB Plot and CIC would receive signals so they could plot and otherwise conduct the problem.

(U) After analyzing the SQS-26 Sonar operation in the operational setting, this level of simulation appears to offer little advantage for ASW team training. It would not provide the capability for lost-target search, which will be a frequent occurrence under the required long-range detection mission. It would not permit the simultaneous tracking required when two targets are observed in either the Uni or Omni channel or one in each. Nor would it permit data on two targets to be passed to CIC and BRIDGE for practice in making the necessary decisions involved when two targets are threatening.

(U) This level of simulation would not provide training for the entire sonar team or the entire ASW team. It would provide a very limited simulation of one part of the SQS-26 and only limited ASW training for the ships crew. For these reasons, this level of simulation is not recommended.

LEVEL 3-SQS-26 SURFACE DUCT SIMULATION ONLY

(U) The next level of simulation considered is the provision of the SQS-26 Onmi-channel capability only. This level would ignore the long-range detection on the Uni channel in the convergence zone and bottom bounce modes and also the passive detection capabilities of DIMUS. These modes would be omitted on the basis that their capabilities are beyond the range of the ASROC weapon. That is, the 14A2A Trainer would be classed as a terminal attack trainer only and no attempt would be made to provide ASW training of SQS-26 ships, personnel for other than detection in the Omni channel and own ship attack.

(U) This level of simulation would replace the SQS-23 with a similar capability using SQS-26 equipment. At this level, the ODT and RDT modes should provide good realism. The B-Scan and Tracking consoles would be provided and completely functional, while only selected buttons on the A-Scan console would function.

(U) Realistic video would be supplied to the PPI and B-Scan displays on the B-Scan console and to the SSI and GI displays on the Tracking console. Comparable audio should be supplied to both operators. The DIMUS unit and test set console would not be supplied with this level of simulation.

(U) This level of simulation would permit practice on almost all of the ASW problems involving the use of the Omni channel. It would permit long range detection and tracking of targets beyond the range of own ship's weapons, subject only to insertion of ocean conditions that would provide long range detection. At these long ranges, SAU attacks could be simulated with other surface ships or aircraft.

(U) Multiple targets could be detected and tracked but in the Omni channel only. The coordination involved in tracking targets in both channels with both simultaneously, A-Scan and B-Scan consoles would not be provided.

(U) The foregoing indicates that this level of simulation is acceptable and adequate for part of the training required for ASW crews on SQS-26 ships. The two consoles provided would permit equivalent training for SQS-26 ships as that now provided for SQS-23 ships. However, it does not provide training for all ASW situations encountered by SQS-26 ships since it does not include use of the Uni channel, CZ and BB modes. On this basis, this level of simulation cannot be recommended.

LEVEL 4-COMPLETE SQS-26 SIMULATION (with exception of minor components)

(U) This level of simulation would provide a complete SQS-26 capability for the 14A2A Trainer. The primary objective of this level would be to permit an interchange of the SQS-23 unit with an SQS-26 unit of comparable and equivalent capability. An equivalent capability would be more complex because the SQS-26 system is more complex than the SQS-23. This level would require no extension of the capability of the 14A2A except that provided by the more complex and sophisticated SQS-26. This level would provide all four operator consoles; namely, the A-Scan, B-Scan, Tracking and DIMUS consoles, and the test set console. Realistic audio and video would be necessary and most displays and controls would be functional.

(U) With this level of complexity added to the current 14A2A Trainer, comprehensive one-ship ASW team training for SQS-26 ships would be possible. A target could be detected at long ranges in the CZ and BB modes. The target could be tracked, closed, and attacked with ASROC or an aircraft could be vectored to datum to localize the target and drop a weapon to destroy the target.

(U) This capability and problem situation will closely match a highly likely tactical situation with SQS-26 ships. As such, it should be practiced so that all skills and coordinations required can be maintained at a high level.

(U) If an attack by Own Ship is desired for training, the target could be detected in the CZ mode, tracked through the BB area, into surface detection range, and finally into range of the weapon. To reduce time, the problem could also start with the assumption that the target had escaped long-range detection and suddenly appeared in the surface duct at close range. The attack would then occur as with the current SQS-23 configuration.

(C) Another problem which is expected in SQS-26 tactical situations and which will require training is the simultaneous tracking of two targets. Since the 14A2A already has a two-target capability, this level of sonar simulation would permit placing the two targets at ranges to 60,000 yards or more on any bearing. Problems could be set up to utilize all modes in various tactical and ASW situations with own ship either in the support role, the attacking role, or in a supporting role on one target and an attacking role on the other target. With this level of simulation, own ship could function in a single-ship problem or as one ship in a multiunit problem with instructors assuming the roles of the other units. This level would keep the problem generation capability of the current 14A2A

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essentially the same except that ranges and problem solutions would be greater due to the capability of the SQS-26.

(U) This level of simulation complexity is recommended as the minimum-cost solution to the basic question posed by the purpose of the study.

LEVEL 5-COMPLETE SQS-26 CAPABILITY AS AN INDEPENDENT TRAINER

(U) This level of simulation complexity and sophistication follows naturally from the Level 4 capability. This level is proposed to permit training of SQS-26 operators and teams with the equipment in an independent mode of operation as well as in conjunction with the 14A2A Trainer. The independent mode of operation would provide a very effective means for operator training of new SQS-26 Sonar personnel.

(U) The hardware maintenance trainer now used for operator training provides only an orientation to the equipment. It does not provide realistic ocean conditions, reverberation and noise. While various modes can be set up, the realism of the problem in these various modes is missing. The target is always visible and the actual signal-to-noise ratio found in the ocean is not provided.

(U) The level of simulation necessary for effective ASW team training as proposed in Level 4, if operable in an independent mode would provide realistic noise, reverberation and target conditions. Thus, if the equipment and signals at the desired level of realism were available via the SQS-26 simulator in the 14A2A Trainer, better initial operator training would be provided than is currently available with the much less realistic maintenance trainer facility.

(U) An independent mode may permit the simulated attachment of the SQS-26 Sonar to one of the support units rather than to own-ship. The sonar team could then detect a long range target and vector in own ship for the attack using the SQS-23 Sonar. This arrangement would permit the SQS-26 Sonar team from one ship to receive training in long range detection while the ASW team on Own Ship could function in the same problem. Additional instructors would be required to man the SQS-23 Sonar and provide communications.

(U) Another advantage of the independent trainer is the flexibility it permits in scheduling operator training. If the SQS-26 addition were independent it could be used for operator training while the 14A2A Trainer was in use in an ASW problem with a crew from an SQS-23 ship. As long as SQS-23 Sonars continue to be used in the fleet, the crews from these ships will need time on the 14A2A Trainer with its SQS-23 Sonar. This time would be available for operator training on the SQS-26 equipment in the independent mode without interfering with the problem in the 14A2A Trainer. Similarily if the SQS-26 capability were independent, the training of operators could proceed without interfering or interrupting the maintenance training schedule on the maintenance trainer hardware.

(U) While the Level 4 trainer fully meets the basic trainer purpose, it is recommended that the SQS-26 training capability be built with an independent mode so it can be used separately from the 14A2A. The flexibility in scheduling

and greater utilization of both SQS-26 and 14A2A capabilities appear to make an independent trainer very desirable. (The minimal added cost as shown in figure 13 also suggests this approach.)

LEVEL 6-COMPLETE SQS-26 SIMULATION AND AN INCREASE IN THE TRAINING CAPABILITY OF THE 14A2A

(U) It is believed that a greater degree of realism in training can be achieved by increasing the capability of the trainer in several ways. Although the addition of the SQS-26 capability described in Levels 4 and 5 would maintain the current effectiveness of the ASW trainer, it is felt that this greater degree of training realism should be considered where appropriate.

(U) The first increase in capability that could be made at relatively low cost envisions the addition of a SAU commander's station in the trainer. This station would add a small degree of realism to SAU training exercises. In the current trainer, the instructor can provide only limited inputs to represent the unit commander and units other than own ship. This level of simulation proposes adding capability for a station with minimal but sufficient equipment to conduct a SAU problem with a SAU commander.

(U) The equipment necessary would be limited to status boards and communication gear and perhaps a radar repeater. This equipment, manned by the necessary plotters and talkers, would permit the current trainer to be set up as a two or three ship SAU using the existing trainer support units. The aircraft and helicopter unit already available would permit a variety of units to make up the SAU.

(U) To accomplish this level of complexity, it is proposed that the complete SQS-26 unit be added and in addition a unit commander station and support unit detection and attack capability. This support unit ship would be controlled by the instructor as is done now. With this addition, own ship personnel would get more realistic SAU training and the SAU commander could also get some desirable experience.

LEVEL 7-COMPLETE SQS-26 SIMULATION AND BROADEN SQS-26 CAPABILITY TO PERMIT TWO-SHIP PROBLEMS

(U) The primary purpose of this level would be to provide the capability for a two-ship trainer. The two-ship trainer would have interchangeable SQS-23 and SQS-26 Sonars, two CIC's, a bridge on one ship, a SAU commander's station on the other, one FCS station for attack, and miscellaneous other facilities currently on the 14A2A.

(U) All stations could be connected in various combinations to provide a wide choice of problems including independent problems. That is, one-ship or two-ship problems could be conducted as well as two independent one-ship problems.

(U) This level would require the addition of one complete SQS-26 capability, as stated in Level 5, the unit commander station, and one additional CIC. These facilities added to the current 14A2A Trainer would provide a comprehensive and desirable single or multiple ship ASW team training capability.

LEVEL 8-COMPLETE SQS-26 SIMULATION PLUS ONE ADDITIONAL 14A2A

(U) This level involves the addition of a separate and complete 14A2A Trainer to the current facility. This addition would have the SQS-26 capability with the existing trainer maintaining the SQS-23 capability. If these two trainers were placed side by side, they should be coordinated so that interdependent two-ship problems could be conducted.

LEVEL 9-SAU TEAM TRAINING FACILITY

(U) This level of simulation would be necessary to provide completely realistic and total-team training for all teams involved in a SAU. It would require multiple facilities, as described above, and an increased computer capability to integrate and coordinate the entire complex. The advantages gained by such a complex would be the provision of realistic communication training between ships, realistic deployment and coordination of ships, realistic interference of sonars, wakes, and action of all the units involved in the SAU.

(U) This type of training would be very beneficial and desirable, but recommendations on specific facilities and capabilities are beyond the desired result of the current study.

COST COMPARISONS

(U) Figure 13 is an attempt to show the comparative costs of adding these various levels of simulation complexity to the 14A2A Trainer. The comparisons of probable costs are based on broad estimates only and, as such, are not definitive nor adequate for budgeting purposes.

(U) Since the Level 4 trainer is the lowest cost device which appears to meet the minimum requirements determined by the study, its cost has arbitrarily been placed at 100 percent. Level 1, 2, and 3 devices are less complex trainers and do not appear to fulfill the training requirements but they would cost proportionally less as shown. Level 5 and 6 trainers could be obtained at the relatively minor additional costs of 3 percent and 6 percent more than the Level 4 trainer. Trainers of Levels 7 and 8 would cost approximately 16 percent and 83 percent more, while a trainer of Level 9 would probably cost over three times as much as a Level 4 trainer.

SECTION VII

RECOMMENDED DISPLAYS AND CONTROLS FOR OPERATOR TRAINING

INTRODUCTION

(U) The discussion in the foregoing sections shows that a realistic operator situation has a great many benefits in training. The level five degree of simulation as discussed in Section VI recommends that all four operator consoles and both the Uni-channel and Omni-channel be simulated for comprehensive training.

(U) These consoles and face plates are shown in Section II as figures 2 through 9. A list of all control and display components on these panels is provided in Appendix A. Also shown is the type of control or display indicator, the initial indication for system checkout, and a description of the purpose or function of each component.

CONTROLS AND DISPLAYS RECOMMENDED FOR OPERATOR TRAINING

(U) The recommended controls and display indicators for operator training are shown in column five of the Appendix A table. These recommendations are based on the analysis of the training problem, the task analysis of operator activity, and the training requirements discussed in Section V.

(U) The entries in column five show that most of the displays and controls are recommended for inclusion as functional components for operator training. In the trainer, these components should effect the simulated transmission and reception of underwater sounds in the same manner as they do on the operational equipment with real signals in the at-sea environment. The controls for the CRT and console lighting should be included to permit the trainee operators to adjust brightness levels, contrast, and CRT storage time to their personal preference or to match the levels they are accustomed to on own ship.

(U) When problems are presented with difficult discrimination tasks due to severe noise conditions, the trainee operator should learn and be able to optimize the detection with appropriate equipment settings. In fact, selected problems should be presented which require the trainee operator to use each of the various controls to optimize the display.

(U) In team training, the problems should require the same performance and be as difficult as at sea so that realistic delays, errors and inaccuracies due to the sonar conditions will be added to the situation to effect the rest of the attack team realistically.

CONTROLS AND DISPLAYS RECOMMENDED FOR MALFUNCTION TRAINING

(U) Most of the time spent in training in the proposed SQS-26 Sonar Trainer should have all equipment operating properly. But the occasional breakdowns which occur at sea also indicate that operators should learn to function when various malfunctions occur in the equipment.

(U) Included in column five in the table in Appendix A are entries which indicate which components could be dummies if malfunction training was not necessary. These components are primarily indicators and pushbutton lights which illuminate when a malfunction occurs and remain illuminated until the malfunction is removed or corrected. The indicators which illuminate when a malfunction has occurred and require a change in sonar procedure are TRUE/REL, STAB OFF/DMho OFF, and SYSTEM OV HEAT/CABINET OV HEAT. Other malfunctions in system operation may also occur to require alternate procedures, but these will not be indicated by lighted face panel indicators.

(U) It is recommended that these malfunction conditions and indications be provided in the trainer.

CONTROLS AND DISPLAYS WHICH NEED NOT BE FUNCTIONAL IN THE TRAINER

(U) Column five in the table in Appendix A shows entries as "DUMMY" if the inclusion of an operational component is deemed unnecessary in the trainer.

(U) Components which are so recommended should be included only for appearance. The HORIZONTAL RANGE - KILOYARDS dial, and the TARGET DEPTH - FEET dial are the two main components which can be omitted. The associated target depth CRT however is recommended for inclusion. Personnel on the USS Fox used this CRT indication to determine if a contact had depth. If multiple echos were seen, the contact was obviously submerged even though the actual depth could not be determined. The I(RA) AVAIL pushbutton light can be a dummy since the operator will not use it.

(U) The target depth cursor knobs on the A-Scan shelf should be included but need not be connected to cursors on the target depth CRT. While the absence of the cursors will be unrealistic, the cue function they perform is so limited that their absence will have no appreciable effect on training. The hand key pushbutton on the B-Scan console shelf can be a dummy since hand keying the transmitter for communication is not necessary in the ASW trainer.

(U) A number of CRT adjustment controls have been listed as dummies in column five. These controls serve no purpose for training and therefore, if not needed for trainer maintenance, may be provided as dummies only in the trainer.

(U) A number of controls on the test set console control panel can be dummy also. The test set console is recommended for inclusion in the trainer to allow the trainees to checkout the equipment as they do in the operational setting. The only controls required are those necessary to set up the simulated target for display in the appropriate mode. Others which are used to test the equipment function rather than to test system performance can be omitted. Column five in Appendix A shows which controls and displays should be operational. All others can be dummies.

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SECTION VIII

RECOMMENDED PERFORMANCE EVALUATION SYSTEM

INTRODUCTION

(U) A very desirable portion of any training situation is the determination of the skill level of the trainees upon completion of the training program. An evaluation of trainee's performance should be made in some manner to determine if the trainee meets the minimum requirement of some higher level of skill. This evaluation is frequently a very sensitive problem since it can have a major effect on morale and the trainee's career and progress in the Navy. For these reasons, evaluations must be valid and reliable indications of performance on a fair test or problem. The problem must be a true test of the skill and ability of the man to perform the task.

(U) This is particularly true in trainers and simulators which are not perfect representations of the actual operational world. Thus considerable care must be exercized in developing the test situation and in drawing conclusions or making judgments about the trainees performance on the test.

(U) The evaluation of the performance of men in trainers and simulators can be based upon both the personal observations of the instructor and objective records and scores. Evaluation of performance based on personal observation is accomplished by comparing the observed performance with what the instructor feels is the standard or desired performance. What did the trainee do compared with what he should have done, or what others have done?

(U) Evaluations based on objective records or scores are made by comparing numerical values earned or scored with other numerical values. These other numerical values are the standard of comparison and may be the average of what others have scored, the best which anyone has ever scored, or an arbitrary standard or score, irrespective of the actual performance of others.

(U) The advantages of using the personal observations of instructors in training situations is that the instructor can modify and adjust the standard or desired performance level and excuse lapses in performance due to extraneous factors. He can observe improvement in performance from problem to problem even though the problems are not comparable and even though he may have actually assisted the man in the observed performance. This flexibility permits the instructor to modify the problem to fit the training or performance limits of the trainee and still rate or compare the trainee performance with some hypothetical standard. The use of personal observation also permits an evaluation of trainee's activity in terms of a subjective numerical rating. Verbal communication, for example, does not lend itself to scoring other than by the subjective judgment of the instructor.

(U) Numerical scores, on the other hand, are based on objective measurements on records and cannot be modified by the instructor's personal judgment. These scores should only be used when the problem conditions are fixed so the scores obtained by an operator will be comparable to scores obtained by others. When the instructor functions as one of the variables in the problem, a "results"

score reflects the instructors performance as well as the trainees' performance. For example, if the instructor is steering the submarine and attempting to evade the trainee sonar operators, any score will reflect the instructor's ability in the problem as well as the trainees.

(U) When the instructor modifies a problem situation to increase or decrease difficulty during the course of the problem for the purpose of training, scores for the problem are not comparable with the standard.

(U) In trainers and simulators, the use of numerical values and scores must be based on the type and purpose of the problem being run. If the problem is conducted to train the operator and the instructor functions as coach or teacher, the score should not be counted since the problem conditions are not standard. In this case it is desired to have the trainee concentrate on learning and not on scoring well. If the problem is set up for the trainee to practice his performance, or specifically to test the trainee's performance, the instructor must be very careful to maintain a standard situation and not bias or influence the results. He should set up and control the problem according to a standard plan and not help or hinder the trainee's performance. (His attitude toward helping the trainee must be different than when he is conducting a problem for training)

(U) If the instructor has successfully maintained standard conditions on the test problem, the scores, time and accuracies can legitimately be compared with results made by other trainees who performed on the test problem under the same standard conditions. This data will then be an objective measure of performance and not biased by the personal subjective opinions of the instructor. It is recommended that evaluation of the performance of the operators in the SQS-26 Sonar Trainer be based on both the personal observation of the instructors and on the numerical data available in the system. The instructor's observations are required to provide evaluation of some of the procedural and communication errors on which data cannot be collected. The data recording capability of the problem computer can be used for collecting data associated with accuracy, timing, tracking, and various events. A computer program can then process and summarize this data for evaluation scores and records.

PROCEDURAL EVALUATION

(U) The SQS-26 Sonar System requires long complex procedures to set up and operate the equipment. The operators and supervisor must know and follow these procedures for optimal performance of the system. The instructor in the trainer should observe the trainee's procedures, provide feedback information during the training and record instances of error for discussion during the critique period. Some of the procedural errors which should be noted are:

1. Improper checklist completion.

    a. What errors were made?

2. Improper search procedure for a mission.

    a. What sector was selected?

b. What mode and equipment setup was used?

c. What search procedure was used?

d. What should have been selected and used?

3. Improper equipment settings for echo enhancement and tracking.

a. What mode and settings were used?

b. What mode and settings should have been used?

c. Were proper changes made, or attempted, to improve detection?

d. Were proper changes made in equipment modes and control settings to enhance and classify target?

4. Improper lost contact procedure.

a. Were 10° bearing checks used?

b. Was proper range setting used?

c. Was position keep used properly?

d. Were proper regain contact procedures used?

COMMUNICATION EVALUATION

(U) Communication in the SQS-26 Sonar operation will occur between the sonar operators, between the operators and the sonar supervisor, and between the sonar team and other personnel on the ship. For smooth operation, this communication should follow standard procedures, even though these procedures may be unofficial.

(U) Communications within the sonar room is a particularly acute problem with operation of the SQS-26 Sonar. This problem is caused by the necessary coordination between consoles when each operator is concentrating on his respective display and listening to the audio. The supervisor must communicate with the operators, pass on equipment operation orders, get their opinion regarding the contacts, and pass on decisions to change modes and intervals. This communication cannot be accomplished while the operators are also listening to sonar audio on the earphones. Therefore, the audio listening will be interrupted while the instructor communicates with the operators. Communication between operators will also cause interruptions in listening.

(U) The ability of the sonar team to work smoothly under these circumstances must be monitored and critiqued by the instructors even though the use of the audio channel on the SQS-26 is not critical, and is not expected to be a serious problem.

(U) In the independent mode of operation, the instructor will function as the own ship's recipient of information from sonar and can evaluate the communication he receives. He should also monitor communications between operators and observe the hand signals and signs which will probably be used. In the joint-operation mode with the ASW team in the 14A2A Trainer, the instructor must monitor the phone communication to other team members also. Some of the evaluation questions concerning communication procedures used by the trainees are:

1. Inter-operator Communication

   a. Did the operators communicate effectively?

   b. Was there unnecessary communication?

   c. Were unnecessary questions asked?

   d. Were information exchanges short and specific?

   e. Were required reports made without prompting?

2. Supervisor-Operator Communication

   a. Did the supervisor communicate with the operators effectively?

   b. Were his orders clear and concise?

   c. Were they understood by the operators?

   d. Were hand signals and signs clear and specific, if used?

3. Sonar Team to Own Ship Communication

   a. Were the correct circuits used?

   b. Was the communication according to established procedure?

   c. Were messages clear, concise and complete?

   d. Were contact reports made correctly?

   e. Were additional contacts reported correctly?

   f. Were any transmissions omitted?

PERFORMANCE DATA RECORDING

(U) The data sensing, storing, and processing capability of the computer permits the use of an entirely new dimension in developing scores and records for evaluation of trainee performance. With the computer, vast amounts of data

can be sensed and stored and then selectively processed to yield a large variety of objective performance measures although it is unlikely that all possible measures and records will be meaningful for evaluation.

(U) Valid performance measures and desired levels of performance cannot be predicted with assurance at this time. Performance data so far collected at sea is sketchy and was not obtained under normal sonar conditions. Under these circumstances it is recommended that data be collected in the trainer and that performance standards be developed from this data. Validity of the standards (and transfer of training effectiveness) can then be determined when more data is available in the fleet.

(U) Similarly, it is not apparent at this time which data will be most meaningful for use in critique sessions following each training problem. However, it can be anticipated that different types and amounts of detail data will be useful at various stages in the training process. This will require several recording and evaluation computer programs to provide the data desired. It is recommended that capability for recording and processing multiple programs be provided and that specific data and records be determined after experience is gained with the trainer.

(U) There are two parameters which can be recorded, processed and converted into possible performance evaluation measures. One is time which is recorded whenever any other data is recorded. The other is events which result from changes or check points in the equipment operation. During the processing of data, these events serve as beginning and ending points for determining times, averages, and frequencies. Events which should be recorded and analyzed initially include:

1. Mode Changes
   Identify the mode and record the time when the new mode begins.

2. Interval changes
   Identify new interval and record the time the interval is changed.

   a. SEARCH or TRACK

   b. SSI ON, SSI AIDED TRACK, SSI OFF

   c. AIDED TRACK AVAIL, AIDED TRACK, POS KEEP ON TARGET

3. Equipment setting change
   Record time, switch changed and new setting.

   a. Tilt Angle selected

   b. Manual Range set - A-Scan

   c. Frequency selected

   d. Sector Center selected

e. Stby/Trap selected on A-Scan console

f. FM/PRN selected

g. A-Scan Notch IN/OUT selected

h. XMTR POWER LEVEL selected

i. B-Scan Range Scale selected

j. RDT Sector Width selected

k. Pulse Length selected

l. Single/Multi-Audio selected

m. B-Scan Notch IN/OUT selected

n. PPI Sum/Diff selected

o. A-Scan - B-Scan selected on Tracking console

p. Stby/Trap selected on Tracking Console

4. Onset of Return
Record the time, in seconds, when the ping return first begins appearing. This event will serve as a means to count the number of pings between other events when necessary.

(U) Record data for each contact which appears on any display scope, such as:

1. Time of return

2. Display holding contact:

a. A-Scan

b. B-Scan

c. PPI

d. SSI

e. DIMUS

3. Record type or identity of echo as follows:

a. submarine target

b. surface ship

c. instructor-controlled false contact

4. Actual position from Own Ship

   a. range

   b. bearing

5. Signal/noise ratio. This figure will serve to show the visibility of the contact compared with the background noise. The higher the value, the more easily detected the echo is expected to be.

6. Computer-generated false target rate. This figure will show the level of discrimination required.

(U) Operator generated. Data record digital data and time transmitted:

1. NDT switch release time
2. Range setting of A-Scan cursor
3. Bearing setting of A-Scan cursor
4. Range setting of B-Scan cursor
5. Bearing setting of B-Scan cursor
6. Range setting of SSI cursor
7. Bearing setting of SSI cursor
8. Value set on Range Rate dials

(U) Special Events. Record time and special event code number as determined and entered on the keyboard by instructor. These special events are nonstandard or infrequent occurrences of events which the instructor may wish to time and record. The events may relate to procedural or communication events which need particular stress in the critique period. They may record the number of interruptions, the number of times an improper or non-standard event occurs or may also signal the beginning and ending of a special period which should be omitted from the record and problem score and problem time. Many events can be expected, and therefore assigned a special event number before the problem begins. Additional unexpected events can be assigned a new number and listed in the instructor's notes during the problem. By proper use of code numbers, the instructor can record the time of many such special events for use in analyzing and evaluating the problem.

PERFORMANCE DATA EVALUATION AND DEVELOPMENT OF SCORES

(U) The data can be collected during the problem on magnetic tape and after the problem can be rapidly processed by the computer to provide a variety of analyses, record scores and comparisons for evaluation. Data processing can be done with a standard program with special analysis orders added with the keyboard. The computer processor and printer are fast enough to make all printout material available within a few minutes after the end of the problem.

The typewriter may also be used as a printout device although slower. Among the material available for use in evaluating and critiquing individual and crew performance are time records, scores, and comparisons.

TIME RECORDS OF ACTIVITY

(U) One desirable record for use during the critique period is a printed list of all significant events which occurred and the time of each. The significant events to be printed out would be programmed from the list of recorded events proposed above. This list could include events such as each change of mode, when the operator switched from search to track, and the number of pings used in the track interval before ON TARGET was indicated.

(U) A second list could be limited to times when contacts were visible on the displays. This list could show the actual range and bearing of the target on each ping and where the cursors were placed as evidence of tracking accuracy. This list could also show the signal to noise ratio of the echo on each ping as evidence that the target could have been detected.

EVALUATION SCORES

(U) The evaluation of operator performance can be based on many types of objective scores which are derived from data collected when standard problems are run under standard conditions. A number of these scores can be determined as follows:

1. Detection score

$$\frac{\text{Echoes detected}}{\text{total echoes}} \times 100 = \text{detection percentage score}$$

2. Contact report score

$$\frac{\text{Contacts reported}}{\text{total contacts}} \times 100 = \text{report percentage score}$$

3. Classification score. Number of submarines classed as possible submarines plus number of non-submarines x 100 divided by total contacts = % correct classification score.

4. Improper classification score. Number of submarines classed as NON-SUBS plus number of non-submarines and false contacts classed as POSSIBLE SUBS times 100 divided by total contacts made = % classification error score.

TIMING SCORES (AVERAGE NUMBER OF RETURNS)

(U) As discussed elsewhere in this report, time scores are less significant with the SQS-26 Sonar, than are the number of returns required before an operator takes action. The kind of data and averages which are proposed for evaluation are as follows:

1. Average number of returns required to detect contact.

2. Average number of returns required to detect contact at a given S/N ratio.

3. Average number of returns required to report CONTACT.

4. Average number of returns required to classify NON-SUB.

5. Average number of returns before going to SSI.

6. Average number of returns required to go to ON TARGET.

7. Average number of returns required to report LOST CONTACT.

OTHER SCORES

(U) Other scores which could be obtained with the computer are:

1. Average range of detection in each mode for all detections made.

2. Average signal/noise ratio at time of detection.

3. Average signal/noise ratio at time of detection for skilled men vs. trainees.

ACCURACY SCORES

(U) Accuracy in the SQS-26 Sonar operation is primarily concerned with tracking the target and determing range rate. Tracking accuracy is determined by noting the difference between actual target position and the position indicated by the cursor.

(U) The average tracking error per problem should be computed but also the error per return should be printed in sequence. This type of data would show the extent of the error, the effect of target range on the errror and other effects which would be masked by a simple average.

(U) The possible error in determining range rate is not expected to be a problem but should be printed out for instructor attention if the average is greater than .1 knot.

STANDARDS OF PERFORMANCE

(U) The scores, times and accuracies obtained by a given trainee can be interpreted or evaluated with a higher degree of confidence if other trainee's scores on the same problem are available for comparison. This comparison would show both the instructor and the trainees how the trainee's performance compares with others, whether his improvement compares favorable with others and how far a trainee or team must progress to reach an acceptable fleet standard or skill.

(U) The collection of data for the preparation of fleet standards of performance in the trainer is one of the distinct advantages of the proposed performance evaluation system. This approach will permit a number of trainees or crews to perform on standard problems under standard conditions. Their combined scores, when averaged, can be used as the standard of performance in the trainer. It also identifies a best score or record score to serve as the fleet record. Averages and records for the fleet would be very desirable motivational tools and would create a challenge for successive crews in the trainer.

(U) In fact, it is recommended that averages and records collected and used in this manner would need to be periodically updated. Teams which were below average will strive to reach the average and teams near the top will strive to break the record. Both situations would result in higher overall performance, and increased averages and standards of performance for the fleet.

(U) Beyond the scope of this study, but strongly recommended, is an effectivness evaluation of the SQS-26/14A2A union. Such an evaluation program would serve to ensure that the device and associated training program(s) are designed and used in a manner which will ensure obtaining the maximum efficiency from the device. Also recommended is a follow on study to insure that the transfer of training from a session in the 14A2A to the operational setting is also maximized. Data and information obtained from such an evaluation would also be useful in selecting a realistic standard of performance for use in the simulated environment.

SECTION IX

ANALYSIS OF INFORMATION REQUIRED BY THE INSTRUCTOR

INTRODUCTION

(U) The information and control requirements of the instructor using the SQS-26 Trainer depends upon the kind of training and level of training problem exercise which will be provided. There are two basic kinds of problem exercises which can be provided by the recommended SQS-26 Trainer attachment to the current 14A2A Trainer.

(U) The first kind of problem exercise will be conducted when the SQS-26 Trainer is operating independently of the 14A2A Trainer. These exercises will provide training for the individual operators in the use of the equipment and for the team of men in the sonar room to learn and practice to coordinate activity and communciate effectively.

(U) The other type of exercise will be conducted when the SQS-26 Sonar Trainer is connected to the 14A2A Trainer. In this case, training exercises are for SQS-26 equipped Own-Ship ASW team training and for limited SAU training. In both cases, the instructor will require basic information displays and a number of control capabilities to set up and run the problem.

(U) When the SQS-26 Sonar Trainer is used in conjunction with the 14A2A Trainer, many of the necessary displays and controls are provided on the 14A2A Instructor Control Console. These displays and controls should be utilized when the sonar and 14A2A Trainer are used in the joint mode. In this mode one instructor will be required to man the SQS-26 Instructor Console in addition to the instructors manning the 14A2A consoles. When used independently of the 14A2A and especially in the team training phase, the instructor will need a separate set of displays and controls to conduct the problem without causing interruptions or being physically present in the 14A2A instructor room. A separate console remote from the 14A2A Instructor Console with sufficient displays and controls to conduct the independent problem is required.

INSTRUCTOR CAPABILITIES AND FUNCTIONS

(U) Personnel assigned as SQS-26 Sonar instructors in the proposed trainer must possess a practical knowledge of the operation and use of the SQS-26 Sonar System. Ideally, the instructor should have considerable experience as a Sonar Supervisor preferably with SQS-26 equipment. However, men with this qualification may not be available. Consequently, instructors without SQS-26 experience will require additional training to insure that they have an adequate knowledge of SQS-26 operating procedures, display interpretation, and probable ASW tactics which will be used.

(U) The function of the SQS-26 instructor at the Instructors Console during the Joint Mode of operation with the 14A2A will be the same as that of the instructor who monitors the SQS-23 equipment with the current configuration. This activity will consist of control of the environment parameters and monitoring the performance of the sonar team for post problem critique.

(U) In some problems and with some teams it may be desirable to have a second instructor in the sonar room. This instructor could more easily monitor sonar team activity, provide coaching assistance, and assure that the sonar team is performing effectively. With an inexperienced sonar team, on-the-spot instruction would be particulary effective. With more experienced teams it is expected that the Sonar Officer or ASW Officer will be capable of providing the necessary instruction, coaching or advice. However, an instructor in the sonar room could provide a desirable critique of the overall sonar team performance. During the independent mode of operation, the instructor at the Instructors Console will have a heavier task load than in the Joint Mode of operation. In this mode, the instructor at the console will have to conn Own Ship and submarine targets and control the location and/or motion of other contacts. He must supply the other Own Ship voice contacts to simulate the bridge and CIC functions. His capability to monitor the specific operation of the SQS-26 equipment, in addition, is expected to be limited. Also in the independent mode, a second instructor, physically present in the sonar room appears to be necessary. This instructor can provide the training for system operation, monitor operator performance and observe team coordination. An instructor headset can be readily supplied so that the instructor can communicate with the console instructor when desired.

(U) When new operators are being initially trained, this on-the-spot instruction on equipment controls and display interpretation is considered essential for effective training. However, when a complete Sonar team from a ship is using the SQS-26 Trainer in the Independent Mode for practice, it is assumed that the Sonar Officer may prefer to provide the instruction. The second instructor may be asked to stand by to observe and critique the entire team and the Sonar Officer. This arrangement will permit sonar teams to practice procedures and communications specifically tailored to the ships requirements, rather than a standard procedure that may not be used on that ship. The instructor functions for the various modes of operation are described in table 6.

(U) Until the design of the Instructors Console is frozen and the specific displays and controls are identified, a detailed task analysis should not be attempted. However, when the final design is adopted, this analysis would be helpful to ensure that a realistic allocation of tasks and functions is made between the two instructors.

(U) The following discussion describes the displays and controls necessary for the instructor to conduct various phases of any problem. The conversion of these requirements into specific hardware recommendations is covered in Section X.

PROBLEM CONDITIONS.

(U) Controls are required to setup, insert, or change the conditions which affect the problem. Displays are required to provide the instructor with information about each condition and should show the parameter involved, the range of choices available and the selection which has been inserted into the computer. During the problem, the instructor should be able to see what condition is in effect, and have the control capability to change the condition. Problem condition parameters for the SQS-26 Trainer are recommended in the following paragraphs.

Table 6. Instructor Functions

Independent Mode of Operation	Problem Setup	Problem Run	Post Problem Critique
Console Instructor	1. Set environment conditions and geographic scale 2. Locate and set up own ship 3. Locate and set up submarine (2) 4. Locate and set up controlled contacts 5. Adjust system noise and set up malfunction	1. Modify environment conditions 2. Conn own ship 3. Conn Submarine (2) 4. Conn surface ship contacts 5. Insert and remove controlled contacts 6. Insert and remove malfunctions 7. Supply communication from bridge 8. Supply communications from CIC 9. Energize F.C. aided track 10. Monitor equipment operation and accuracy 11. Control performance data collection	1. Describe problem 2. Describe contact location 3. Describe target maneuver 4. Critique communications 5. Critique equipment operation 6. Critique accuracy of cursor positioning 7. Critique overall problem performance

Table 6. Instructor Functions (Continued)

Independent Mode of Operation	Problem Setup	Problem Run	Post Problem Critique
Sonar Room Instructor	1. Make initial equipment settings 2. Provide problem briefing 3. Monitor check list computations	1. Monitor equipment operation 2. Monitor communications 3. Monitor team coordination 4. Provide instruction on equipment setup 5. Provide instruction on display interpretation 6. Provide instruction on communications 7. May function as Sonar Supervisor 8. May advise console instructor to alter problem difficulty	1. Critique equipment operation 2. Critique communications 3. Critique team coordination 4. Critique check list computations and use of data 5. Critique overall performance
Joint Mode of Operation with 14A2A	Problem Setup	Problem Run	Post Problem Critique
Console Instructor	1. Set environment conditions 2. Adjust system noise and malfunction conditions	1. Modify environment conditions 2. Insert and remove controlled contacts 3. Insert and remove malfunctions	1. Critique Sonar operation 2. May describe target maneuvers 3. May critique sonar communications

Table 6. Instructor Functions (Continued)

Joint Mode of Operation with 14A2A	Problem Setup	Problem Run	Post Problem Critique
Console Instructor (continued)	3. Locate and set up Instructor controlled contact condition	4. Monitor equipment operation 5. Monitor communications 6. May Conn submarine (2)	
Sonar Room Instructor (if used)	1. Make initial equipment settings 2. Monitor check list computations	1. Monitor equipment operation 2. Monitor communications 3. Monitor team coordination 4. May advise Sonar Supervisor or Operator how to enhance displays	1. May add comments to problem critique made by Master Instructor or Sonar Console Instructor

PROBLEM RUN CONDITION

(U) A display is required to show whether the problem is STOPPED, is RUNNING, or is in a FREEZE condition, with controls to change the condition. In the joint mode, the problem run condition should be controlled from the 14A2A master keyboard. In the independent mode, a separate control is required.

SEA STATE CONDITION

(U) A control to select a given level of SEA STATE is necessary. A display should show the range of choices available in the computer and the choice selected by the instructor. Controlling the level of the sea state is a convenient means of controlling the level of noise in the problem. A knob for controlling sea state is currently provided on the support cabinet on the 14A2A Instructor Console but an additional control will be required for the independent mode instructors console.

BOTTOM CONDITIONS

(U) The bottom has a significant effect on the operation of the SQS-26 Sonar System. The four parameters of interest are bottom depth, type, slope, and tilt direction. These parameters do not affect the SQS-23 operation so controls are not provided on the 14A2A console. For training of SQS-26 operators, the range and choices of each of the four bottom parameters must be displayed and controlled by the instructor in both modes of operation.

BATHYTHERMAL LAYER CONDITION

(U) The depth of the isothermal layer must be controlled by the instructor, and displayed during the problem. A bathythermal (BT) control is provided on the 14A2A Instructors Console but an additional control will be necessary for independent operation. It is recommended that a BT chart be provided trainees, corresponding with layer depth and temperatures set in by the instructor. This chart will provide valuable experience in reading the BT message, computing the check list settings, and will provide a means to verify that all operators are completing the check list correctly.

TEMPERATURE

(U) The temperature at the surface or transducer depth and at layer depth are important entries made by trainees on their check list. These temperatures should be input by the instructor and coincide with the BT trace recommended above.

BIOLOGICAL CONDITION

(U) Even though little is known of the exact nature of biological layers and effects, a biological condition should be provided in the trainer under the control of the instructor. The level inserted should be displayed during the problem and a control provided to increase or decrease the condition.

SALINITY

(U) Salinity of the ocean has a minor effect on the speed of sound in the water and thus on apparent range of the SQS-26 Sonar. For effective training, the salinity level need not be varied in the trainer, because its omission would not effect training realism.

OCEAN SCALE

(U) The ocean scale in the 14A2A Trainer is limited to 256 kilo yards. This scale is sufficient for use with the SQS-26 Sonar Trainer also. A similar scale should be provided for use in the independent mode.

EQUIPMENT CONDITION AND SETTINGS

(U) The effectiveness of the SQS-26 Sonar System is markedly affected by the settings made by the operators. These settings should be displayed to the instructor during the course of the training problem to permit him to evaluate the trainee's operation of the console. This information will permit the instructor to recommend a different setting and to monitor the procedure used by the operators in selecting and modifying displays. The settings which should be displayed to the instructor for each console are as follows:

1. A-Scan Console Settings

   a. Mode selected

   b. Interval selected

   c. Tilt Angle setting

   d. Range setting

   e. Zone Width selected

   f. Frequency selected

   g. FM/PRN selected

   h. Notch in/out selected

   i. Sector Center selected

   j. Cursor position - range

   k. Cursor position - bearing

   l. Echo Trap position selected

2. B-Scan Console Setting

   a. Interval selected

b. Transmitter power level selected

c. Range scale selected

d. Pulse length selected

e. Notch in/out selected

f. Single/Multi audio selected

g. PPI Sum/Difference selected

h. RDT Sector Center selected

i. Cursor position - range

j. Cursor position - bearing

3. Tracking Console Settings

a. A-Scan/B-Scan selected

b. SSI on/off

c. SSI or SSI Aided Track operation

d. Echo trap position in use

e. Range rate dial settings

f. Range and bearing settings of the tracking console cursor will be the same as the A-Scan or B-Scan depending on the channel connected to the tracking console. A separate set of range and bearing readouts of SSI cursor position is not necessary.

REPEATER DISPLAYS

(U) The instructor, at his console, should be able to monitor the performance of the operators at their respective sonar consoles. To do this, the instructor should hear and see the same information as that displayed to the operators. This can be done with repeater displays and audio channels for the instructor which duplicate the displays and sounds provided to the operator. However, it is not necessary for all displays to be in view at the same time since usually only one display is of significance and interest at a time.

(U) Similarly, it is not essential that the instructor monitor every return on every display or channel. What is necessary is that he be able to see and hear a series of returns on a given display and channel when the trainee is having difficulty or needs help, or when the instructor wishes to monitor a specific display or channel for critique purposes. The displays required at least occasionally during the problem are:

1. A-Scan display and Uni-Channel audio

2. B-Scan display and Omni-Channel audio

3. SSI Display and audio

4. PPI display

5. GI display

6. DIMUS display - The actual DIMUS display need not be completely reproduced for the instructor. What is minimally required is information that a signal is visible on the trainee's console display.

(U) Controls are necessary to enable the instructor to select a desired display and an indication to show which display is in view.

GEOGRAPHIC PLOT DISPLAY

(U) A geographic-plot display of the problem is required by the instructor to set up and monitor the vehicular motions and contact locations during the problem.

(U) In the 14A2A Trainer, a plot is provided by inscribed slides which show vehicular location and track on a large screen. A sea scape display is provided on the console which shows the instantaneous geographic location of vehicles in the problem either in an own-ship-centered or other-vehicle-centered display. In the attached mode of operation these displays should be sufficient with the possible addition of a contact-location display which is not now provided.

(U) In the independent mode of operation a separate geographic display must be provided to show the necessary information to the instructor. This display may be an own-ship-centered display or an X, Y geographic-plot display selectable by the instructor. This display should show own-ship position and course, submarine target position and course, support ships positions and courses, and the location of each controlled noise source in the problem. When two or more submarines or two support units are involved in a problem, they should be identified by number or symbol. When a vehicle or noise source is activated in the problem, it should be shown on the geographic plot and removed from the plot when deactivated. A scale control of the plot should be provided so that a problem of maximum range can be viewed, as well as an expanded view of a minimum range problem.

VEHICLE AND CONTACT CONTROLS

(U) In the independent mode of operation, all vehicles and targets in the problem must be under instructor control. This will include own ship, target submarines, support ships and some of the miscellaneous continuous contacts which will appear on sonar.

(U) In the joint mode with the 14A2A Trainer, own ship is controlled by the bridge while targets, support ships and contacts are controlled by other instructor personnel.

OWN SHIP CONTROLS (INDEPENDENT MODE)

(U) Controls must be provided for positioning own ship in X and Y coordinates on the geographic plot. Course and speed controls should be provided to permit the instructor to function as the helm during search and closing operations in the independent mode.

SUBMARINE AND SUPPORT UNIT CONTROLS

(U) Submarine and support units must be positioned and assigned courses and speeds. In addition, controls should be provided to activate each vehicle, assign a type designation, and assign a symbol to identify the vehicle on the geographic display. A submarine depth control is also necessary.

(U) To remove much of the work load from the instructor, controls to assign one of a variety of specific maneuvers to each submarine and support unit should be provided. This will permit the instructor to set up the problem, assign a maneuver, and then concentrate on monitoring the operator's actions rather than on steering all vehicles in the problem.

FALSE CONTACT AND WAKES

(U) Two types of false contacts are necessary for the SQS-26 Trainer. One type should be under the control of the instructor, permitting him to place such a contact in the problem and remove it when desired. The second type of contact should be generated by the computer, based on ocean noise and reverberation conditions, and be randomly positioned and appear and disappear at random times in the problem.

(U) The instructor-controlled false contacts require the instructor to have an X and Y position control, a contact type designation control, an identity control, and an enable/deny control. For computer-generated false contacts, one control to increase or decrease the frequency of occurrence should be sufficient.

(U) The instructor should be able to add or remove wake effects from the displays. One control to add wakes to all ships or none would be sufficient.

COMMUNICATION CONTROL

(U) In the attached mode, adequate communications are already provided for the instructor to monitor and communicate with the men in the sonar room.

(U) With an independent mode, the instructor, at his console will need to have communication capability with the sonar room on several channels.

21 MC CIRCUIT

(U) The 21 MC circuit is the command intercom and should be set up so the supervisor can communicate with the entire crew in the SQS-26 Sonar station.

29 MC CIRCUIT

(U) The 29 MC intercom channel should be set up so that all sonar announcements are broadcast on the speaker in the instructor's area. These announcements include "contact", "lost contact", "regained contact", classification information, and similar information normally relayed to the Bridge and CIC intercom speakers from Sonar.

1JS CIRCUIT

(U) The 1JS command and control circuit should be provided for the sonar supervisor to talk on this network as on the actual ship. In the attached modes, the network should actually extend to the Bridge, to CIC, UB Plot, and also to the instructor for monitoring. In the independent mode, the instructor will need to function as all other own ship's stations as well as monitoring the communication.

61JS CIRCUITS

(U) This one-way circuit from sonar to the CIC plotter should be provided to allow the instructor to monitor communication procedures.

SONAR STATION CONVERSATION MONITOR

(U) The instructor station in both the attached and independent mode should be able to monitor the miscellaneous conversations in the sonar room. A hidden sensitive microphone in the sonar room could pick up all conversation for monitoring by the instructor.

AIDED TRACK AVAILABLE

(U) In the independent mode a switch must be provided to signal AIDED TRACK AVAIL to sonar. In the attached mode this light is activated by the Mk 53 operator.

MALFUNCTION CONTROL AND DISPLAYS

(U) It is anticipated that most training problems will be conducted under normal conditions with all equipment operating satisfactorily. However, operators should learn to function with degraded equipment and non-normal conditions which may occur. To provide this type of emergency condition the instructor must have control over various malfunctions in the equipment. It is impractical and unnecessary to provide an approach which would duplicate all possible malfunctions. Rather, it is recommended that a sufficient number of malfunctions be provided to demonstrate that sonar can still provide target data even when partly malfunctional. Practice under these malfunction conditions will be very beneficial for trained but inexperienced operators.

(U) The following malfunctions are recommended for inclusion:

1. A-Scan Display

   a. System adjustment degradation

   b. CP capability off

   c. CW capability off

   d. Both CP and CW capability off

   e. Selected display channels off (1 or 2 of 12)

2. B-Scan Display

   a. System adjustment degradation

   b. Completely off

   c. Display channels off (1 or 2 of 72)

3. PPI Display

   a. PPI Scope display completely off

4. SSI and GI Displays

   a. Both displays completely off

5. DIMUS Display

   a. Display completely off

6. Equipment Malfunction. It is recommended that the following malfunction controls be provided to simulate probable conditions in selected problems:

   a. Stabilization - OFF

   b. DMho input - Off

   c. Gyro input - OFF

   d. System Overheat - ON

   e. Uni Cabinet Overheat - ON

   f. Omni Cabinet Overheat - ON

HOSTILE WEAPON CONTROL

(U) Each target submarine in the problem should be able to launch a torpedo at Own Ship.

(U) One of the sounds that sonar operators must be on the alert for and immediately recognize is that of an enemy torpedo in the water. The displays and sounds provided to the operator should of course emanate from the submarine. The instructor must have provisions for selecting and firing these torpedoes. In the attached mode an existing attack support panel provides this capability. In the independent mode a similar panel should be provided.

RECORDING CONTROLS

(U) As recommended in Section VIII, a large amount of data can be recorded on magnetic tape with a digital-computer controlled trainer. The instructor should have the option of turning the recording system on and off and selecting one of several recording programs. Several recording programs are recommended for flexibility. Similarly, the instructor should be able to select one of several levels of evaluation readout for the critique session.

DISPLAYS OF ERRORS AND INACCURACIES

(U) During the course of the problem, the instructor should receive information on the accuracy of the operator. This data will permit the instructor to give on-the-spot coaching or guidance by intercom. This type of instruction is particularly helpful to orient new sonar operators and to check and correct the performance of experienced men from the fleet. Improper performance can also be noted and discussed later during the critique sessions if desired. The data which should be supplied to the instructor during the problem is as follows:

Cursor Positioning

(U) The positioning of the cursor on both omni-channel and uni-channel echoes compared with the actual position of the target should be displayed to the instructor. This can be done on the sonar repeaters, on the geographic plot, or by digital readouts of the respective locations.

Range Rate

(U) The range rate determined by the SSI operator should be displayed to the instructor for comparison with the actual range rate.

Contact and Classification Data

(U) Errors in detecting or locating contacts and subsequent errors in classification should also be available to the instructor. Since much of this data will be transmitted by intercom, the instructor will need to match the verbal data with the actual situation as seen on his geographic plot.

Tracking Data

(U) Accuracy of tracking by sonar operators is very important and is done on a ping-by-ping basis. The instructor can observe the accuracy of cursor positioning after each ping as above, but can not obtain an overall tracking accuracy record. Overall accuracy data must be provided in a post problem review.

Scoring and Evaluation Data

(U) Besides the observation and comments the instructor can make during a problem, the instructor should have data to provide scores and evaluation levels to trainees during the critique session after the problem. These objective scores and evaluation grades can serve as an excellent motivation device, but more important they provide a progress report to the trainee and the team. Of particular interest to trainees in regard to performance level, speed of progress and terminal skill level is the comparison of these levels with a standard or with other ships in the fleet. Comparison with an average of other ships in the fleet is the most meaningful and it is believed will provide the most effective motivation. Such an average will also be accepted much better than will comparison with arbitrary standards or scores. A complete discussion of the recommended performance evaluation system is given in Section VIII.

SECTION X

RECOMMENDED DESIGN OF THE INSTRUCTOR'S CONSOLE

INTRODUCTION

(U) The addition of an SQS-26 Sonar System to the existing 14A2A Trainer requires an expansion of the instructor's console to accommodate the displays and controls necessary for instructor operation of this added capability.

(U) Two modes of operation are recommended for this added capability. These are: (1) an attached mode in which the operation of the SQS-26 Trainer will be integrated with the 14A2A Trainer for comprehensive ASW problem exercises, and (2) an independent mode of operation in which the SQS-26 capability can be operated separately from the 14A2A Trainer for individual and team sonar training exercises. Each of these modes of operation will require a set of instructor displays and controls as described in the following paragraphs.

JOINT MODE OF OPERATION

(U) In the joint mode of operation, many of the controls and displays needed by the instructor are presently provided on the 14A2A Instructor Console. All vehicle and weapon controls, the problem controls and the ocean and geographic displays are provided.

(U) A sea state control and a layer depth control are presently provided to control the environment for the SQS-23 Sonar. It is recommended that these two controls be duplicated on the SQS-26 instructor's panel for convenience.

(U) The type of cabinets for the recommended Instructor's Console for the SQS-26 attachment to the 14A2A is shown in figure 14. These cabinets are identical in size and design to Units 5A01 and 5A02 of the current console. The recommended control panels are laid out as shown in figures 15, 16, and 17.

(U) The environment control panel contains the four bottom-condition controls: depth, type, slope, and tilt. Two temperature controls are provided for surface and layer depth temperature. This panel has the sea state control and layer depth control mentioned above. Also provided are a control to vary the frequency of occurrence of computer-generated false-target echoes, and a control of DIMUS range.

(U) New displays are recommended for the instructor to monitor the complex activity of the SQS-26 Sonar team. One display is recommended which can provide selectable repeater displays of the A-Scan, B-Scan, Graphic and Sector Scan Indicators. This same display can also be used to display an own-ship-centered geographic plot. Selection switches permit the instructor to choose and observe any display at his discretion. Five choices of display scale are recommended for the geographic plot.

(U) A second display is also recommended to provide a repeated PPI or target depth display. This second PPI type repeater display eliminates the considerable complexity necessary for it to be combined with the first display mentioned above.

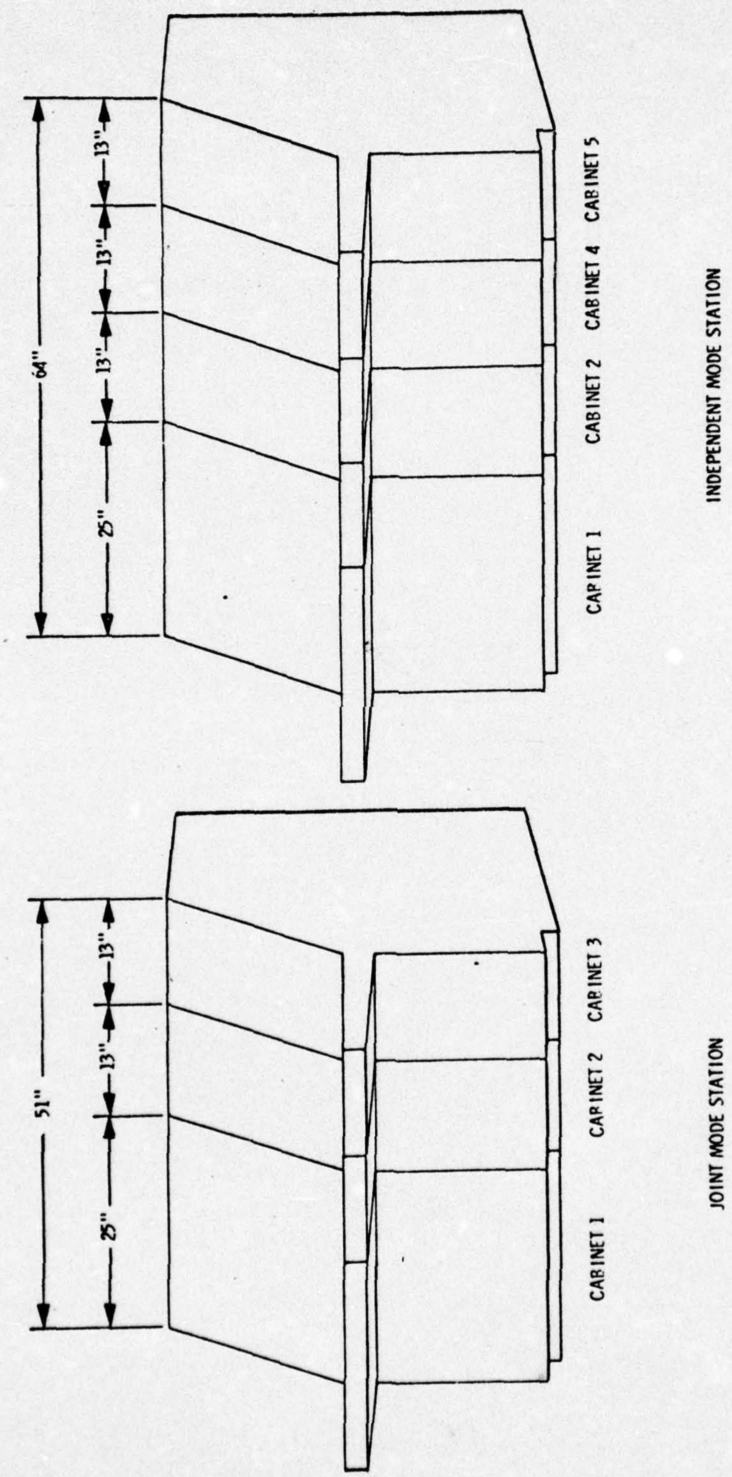
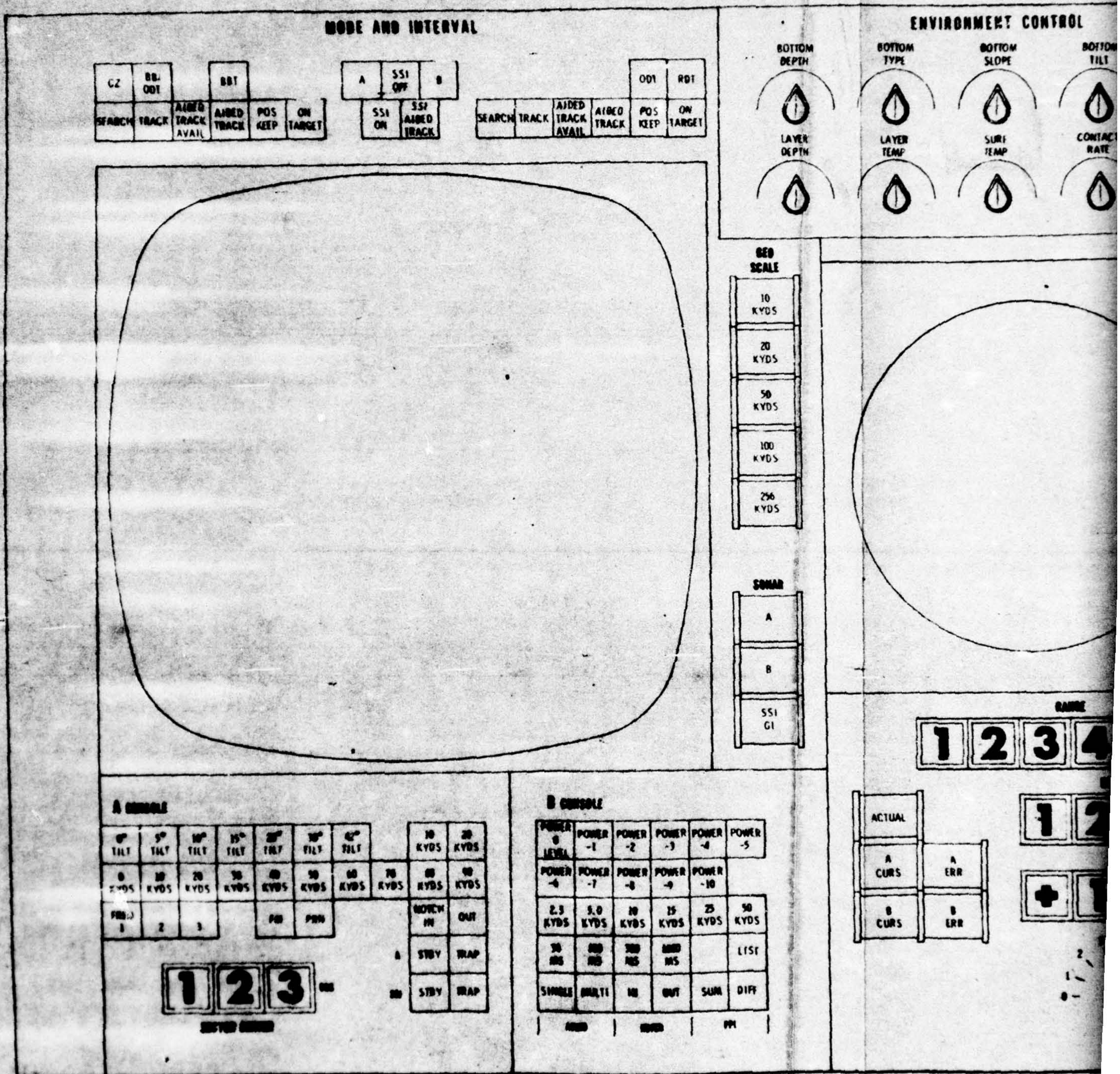


Figure 14. Cabinet Configuration, (Both Modes)

CONFIDENTIAL



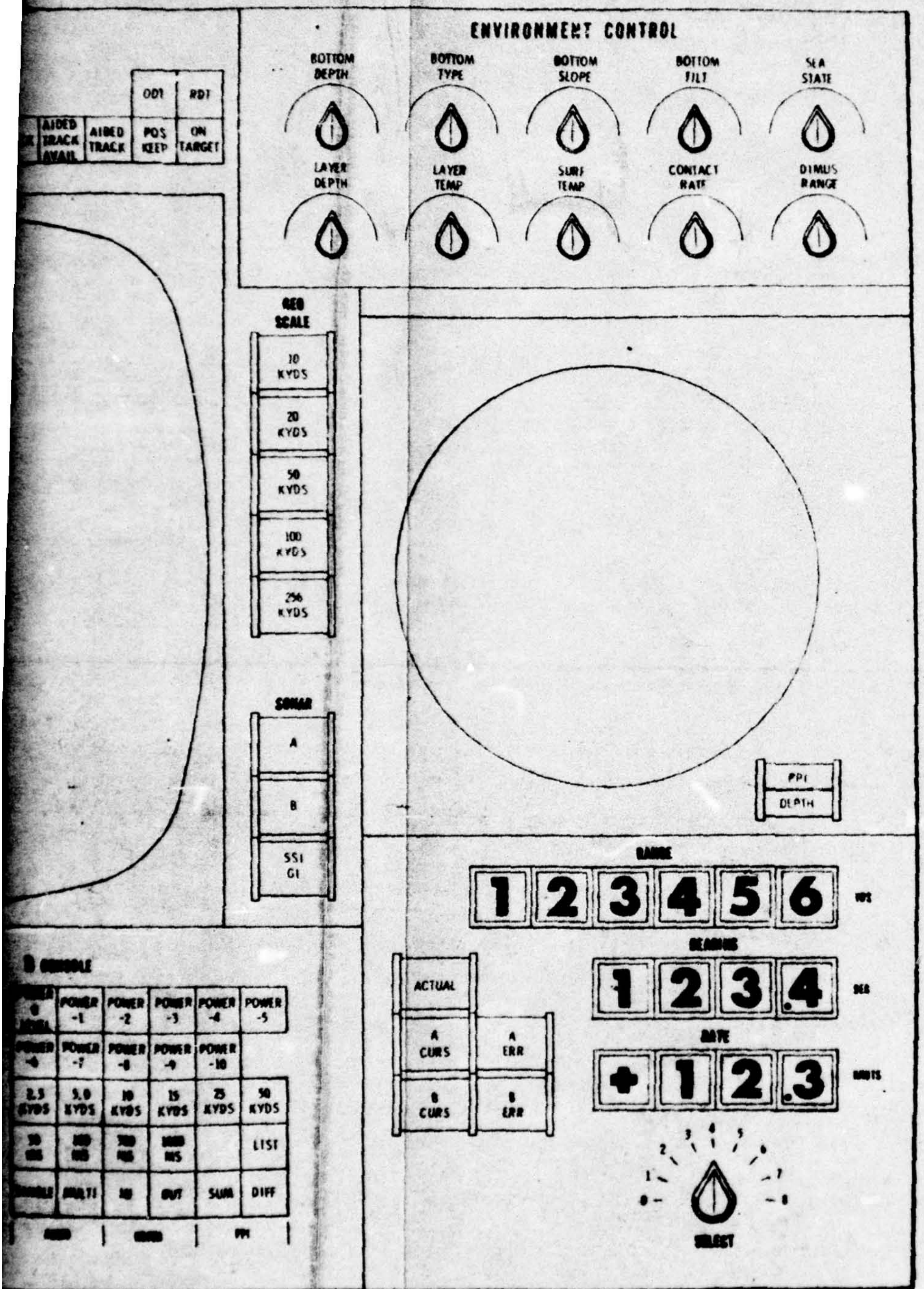


Figure 15. Displays and Controls, Instructor's Console

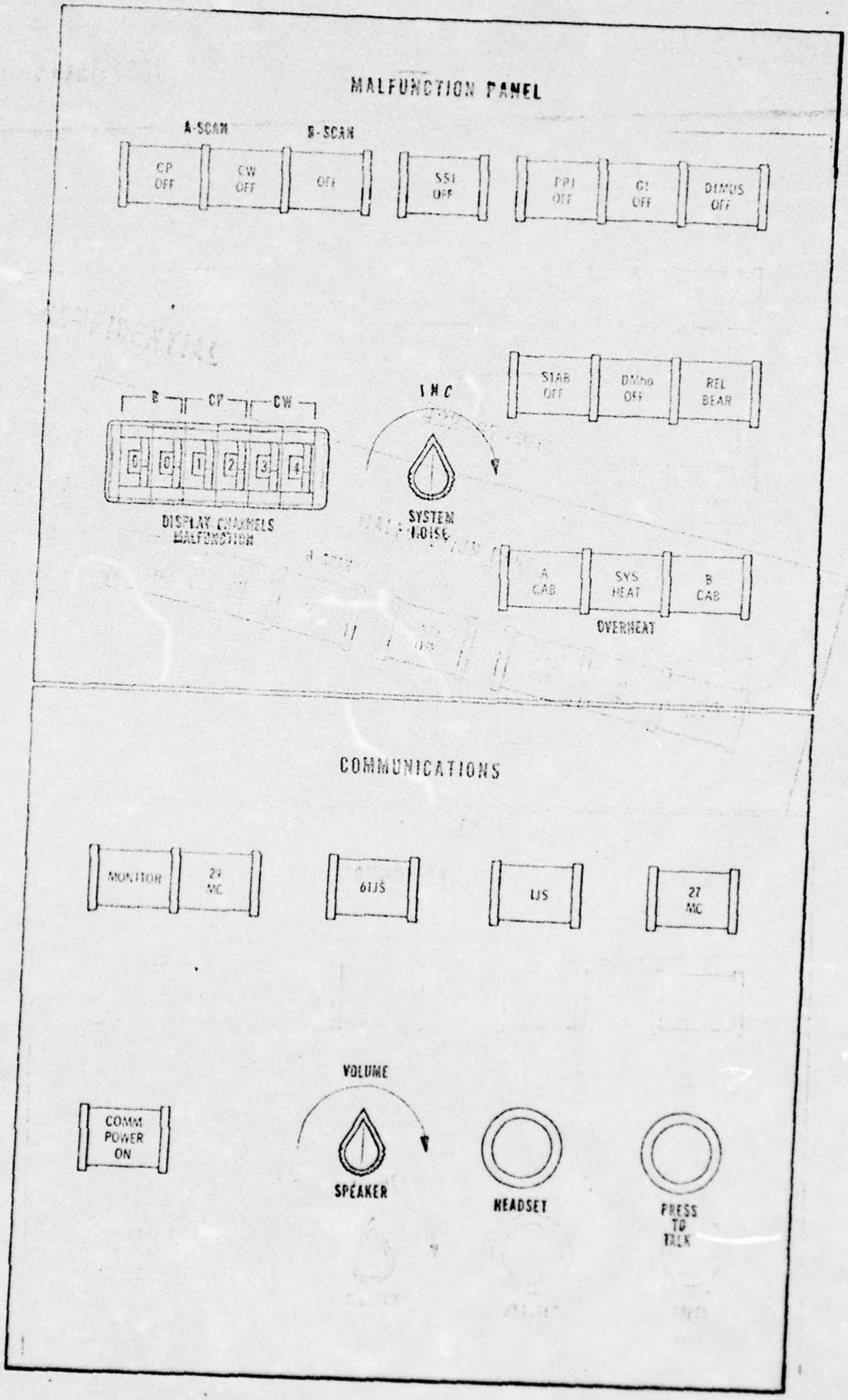


Figure 16. Malfunction and Communications Panels, Instructor's Console

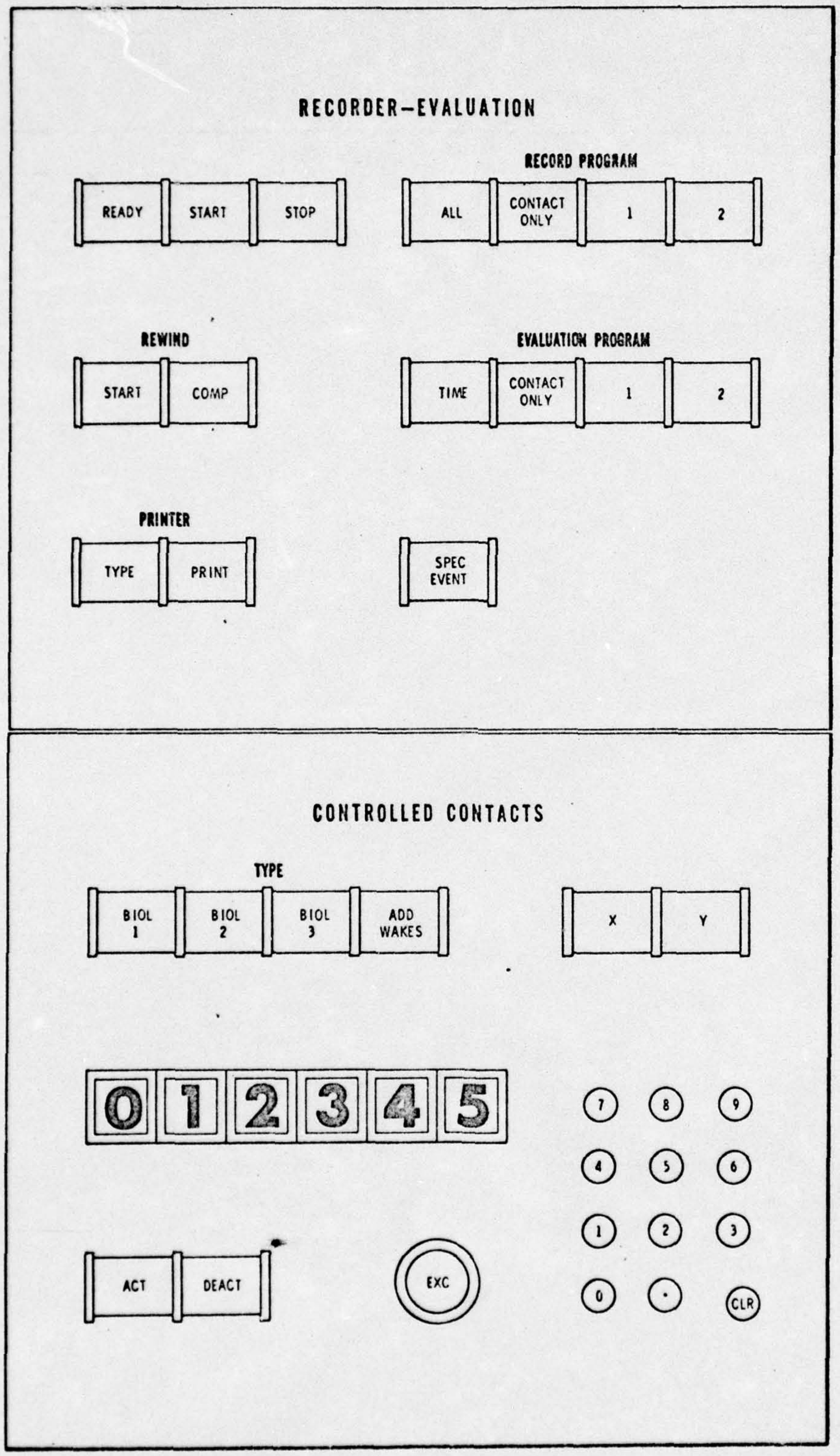


Figure 17. Recorder-Evaluation and Controlled Contacts Panels, Instructor's Console (Attached Mode Only)

(U) Lighted indicators are recommended to show mode, interval, and switch settings in use by the trainee. Figure 15 shows the mode and interval indicators above the main display and switch position indicators below.

(U) The range and bearing to selected targets from own ship is of constant interest to the instructor. He should know the actual range and bearing to each target, the range and bearing indicated by the A-Scan and B-Scan cursors, and the error between the actual position of the target and the cursor-indicated position.

(U) It is recommended that two digital displays be provided for these range and bearing indications and five labeled buttons be provided to make the desired selection as shown in figure 15.

(U) A digital range rate indicator is recommended to display the actual range rate to the target selected by the knob. This entry can be compared with the operator's verbal report of the setting on the dials on the tracking console.

(U) A small number of malfunction control switches are recommended for inclusion on the second unit of the instructor console as shown in figure 16. Ten major unit malfunction pushbuttons, three "overheat" pushbuttons, one variable knob to insert system degradation, and four display channel digiswitch selectors are shown. These malfunction controls will permit the instructor to add realistic equipment problems to the trainer equipment. A separate communication control panel as shown in figure 16 is recommended for use by the instructor who is controlling and monitoring the SQS-26 team in the joint problem.

(U) The third unit of the Instructor's Console has two panels as shown in figure 17. The controlled-contacts panel provides for the insertion of instructor-controlled contacts, such as biological effects, into the sonar displays. The computer will generate random echoes which will also appear. The instructor-controlled echoes can be added to provide a greater quantity of definite contacts than now provided on the SQS-23 Sonar. The extended range of the SQS-26 system permits a greater coverage of ocean and the resulting probability of many more contacts. The controls provide selection of one of three types of contacts, assignment of an identifying number, and digital keys to position the contact in X and Y in the problem ocean. ACTIVATE and DEACTIVATE buttons are provided to enable the instructor to insert and remove the contact during the problem.

(U) The Recorder-Evaluation control panel is recommended as shown in figure 17. This panel contains START and STOP pushbuttons and a READY indicator light to signal that the recording capability is connected and energized. A choice of four recorder programs can be selected by depressing one of four pushbuttons. This capability permits the instructor to record different amounts of detail, depending upon the level of training and data requirements for critiques. One of four data evaluation programs can be selected for different types of hard copy printouts. A REWIND START pushbutton, REWIND COMPLETE light and TYPEWRITER or PRINTER select pushbutton are provided.

INDEPENDENT OPERATION

(U) When the SQS-26 Trainer facility is to be operated independently of the 14A2A Trainer, a separate console in a different room will be required by the instructor. This separate console will permit complete independent operation without interference to the 14A2A Trainer.

(U) The independent operation console should be located close to the trainee equipment. A good arrangement would be to locate the Instructor Console in a room adjacent to the trainer room with one-way glass between to permit direct observation by the instructor. However, the prevailing darkness in the sonar room will limit the direct observation of trainees, so most of the monitoring must be conducted by observing displays and listening to the communication channels.

(U) The complete cabinets and all displays and controls shown on the cabinets in figures 15 and 16 are also required for independent operation. Exact duplication of these cabinets is recommended.

(U) Two additional cabinets are required for independent operation as recommended in figures 18 and 19. These two consoles are required instead of the cabinet shown in figure 17. The Recorder-Evaluation panel shown in figure 19 can be the same as the panel shown in figure 17 but the controlled-contact panel is not necessary. It is recommended that the controlled-contact panel be replaced with an attack-support panel as shown in figure 19. This attack-support panel will enable the instructor to activate hostile torpedoes in the problem. In the attached mode, this attack support is exercised via panels in Units 5A07, 5A10, and 5A11.

(U) An additional pushbutton is proposed on this attack support panel to provide the independent mode instructor with the capability to initiate FCS AIDED TRACK AVAIL. In the attached mode this function is performed by the Mk 53 operator. It is required for independent mode training and procedures.

(U) The controlled-contact panel can be incorporated on the vehicle-control panel in the independent mode console as shown in figure 18. This panel and its cabinet is an additional capability required for the independent mode. This vehicle control panel permits the instructor to activate a vehicle number, assign a vehicle type to that number, position it in X and Y on the problem ocean, assign a course and speed, assign a depth if it is a submarine, and place it on one of several predetermined maneuvers. The same panel is used to assign an X and Y position and course and speed to own ship. These pushbuttons are used in conjunction with the digital keyboard to input numerical values to the computer.

(U) By assigning several of the type-select buttons as biological types and eliminating the course and speed inputs, the vehicles will appear as echoes of kelp, pinnacles, knuckles or other stationary reflectors in the ocean. A total of 8 combinations of submarine targets, surface vessels and biological or other contacts are recommended for the trainer. This many variations will permit the instructor a wide latitude of contact sources for training. He may have as many as 8 submarines only, or 4 submarines and 4 surface vessels or 2 submarines, 2 surface vessels and 4 biological or other contacts in a problem.

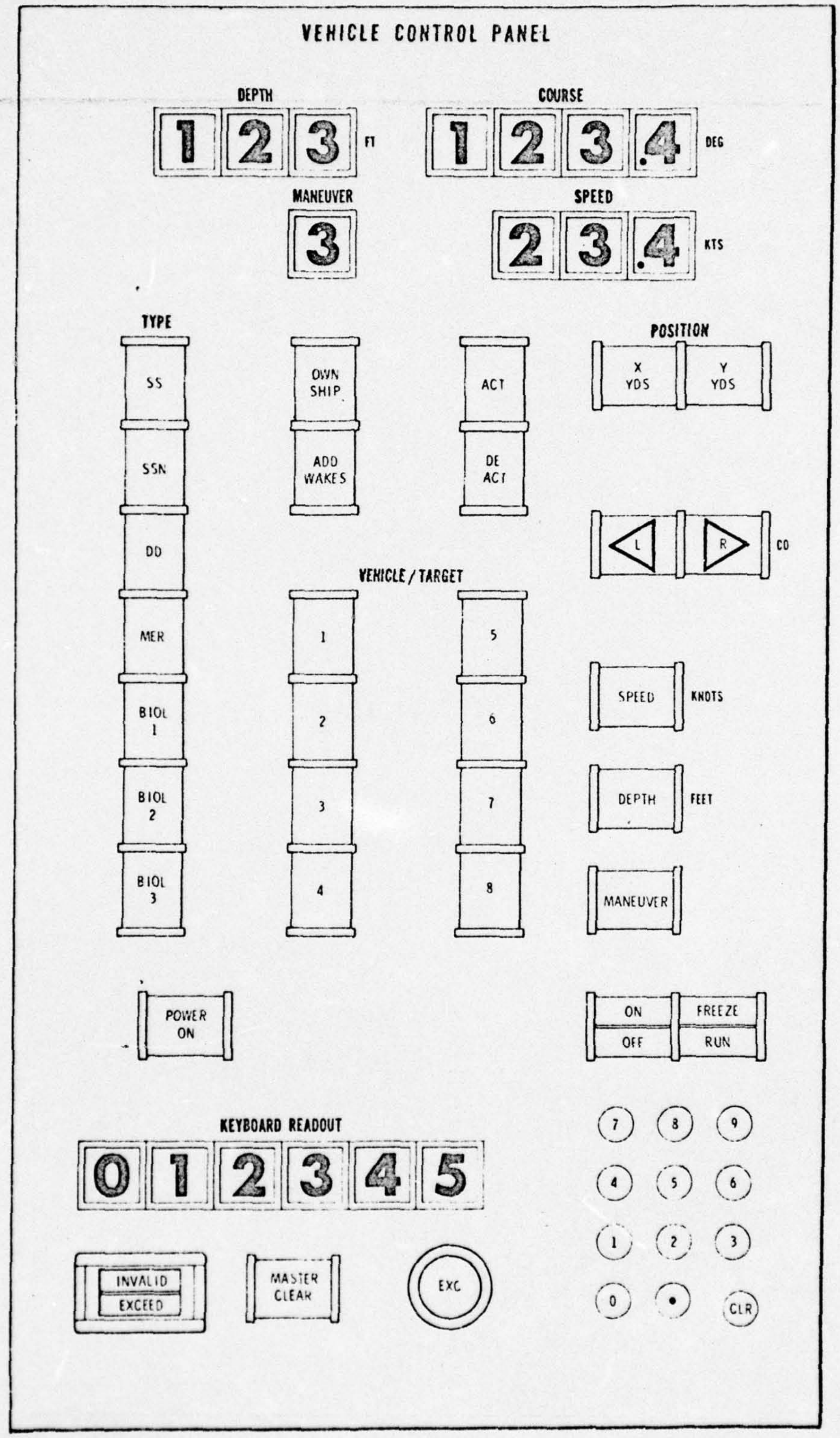


Figure 18. Vehicle Control Panel, Instructor's Console

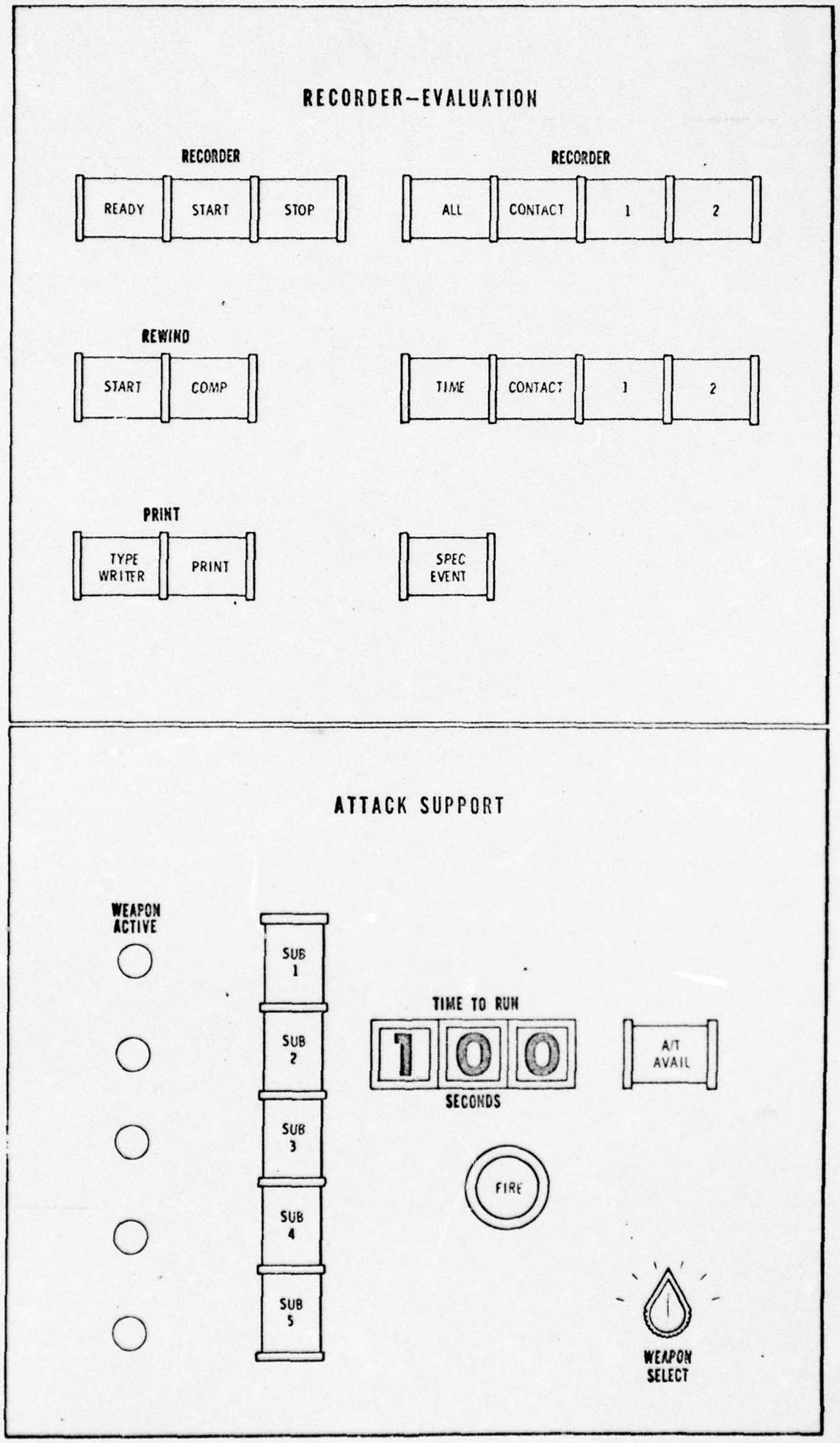


Figure 19. Recorder-Evaluation and Attack Support Panel, Instructor's Console (Independent Mode Only)

(U) As shown in figure 18, immediately above the vehicle control panel are 3 displays related to the vehicle motion. When one of the numbered vehicle buttons or the own-ship button is depressed on the vehicle control panel, the course, speed, and depth of that vehicle is displayed. Also shown is the number of the maneuver code assigned for that vehicle. These displays permit the instructor to monitor and modify the motion parameters of any vehicle in the problem.

SECTION XI

RECOMMENDED LEVELS OF REALISM

INTRODUCTION

(U) The recommended level of simulation includes all four operator consoles and both the surface (Omni) channel and the depressed (Uni) channel for effective training. These recommendations propose a level of simulation but do not specify the level of realism as it effects the operator.

(U) Realism in the trainer can be investigated in five areas: (1) the realism of the training problem and situation; (2) the realism of the simulated sonar room and environment; (3) the realism of the consoles and controls; (4) the realism of the visual displays; and (5) the audio presentation.

PROBLEM AND SITUATION REALISM

(U) Trainees are well aware that they are in a training situation when they are engaged in an exercise in a shorebased simulator. In most cases a concerted effort must be made in the administration of the training program to overcome a lack of interest and motivate the trainees to expend the effort to learn and perform their assignments effectively. The performance evaluation system discussed in Section VIII is one such means for providing motivation. Another motivating influence is the orders and desires of the ships commanding officer, and the esprit de corps of the ships crew to perform well. A third source of motivation is the inherent desire and personal pride of the trainees to learn their task and perform as well as possible. These motivating influences must affect the trainees before they begin training.

(U) In the trainer, the pre-problem briefing must build this basic motivation and can be very significant in helping to create an acceptance of the problem realism. The plausibility of the tactical situation, the tactical orders, and the intelligence information provided to the trainee must create a realistic picture of the problem. The setup of the problem and the apparent reality of documents, charts, etc, must help support this picture.

(U) After the problem begins, extraneous and atypical sounds and noise should be prevented. Similarly, interruptions by visitors, coffee and lunch breaks and other non-standard at sea conditions should be avoided or minimized. Instructors should try to maintain the impression of reality as closely as possible.

(U) While it is impossible to set up a completely realistic situation, everything possible should be done to make it easy for the trainees to get into the spirit of the problem and play their role realistically.

(U) One exception to realism in the 14A2A Trainer, is the lack of ships motion, which is not provided. The realism value is evident but the training value of such capability is only minimal at best. Operator performance is markedly affected by ship motion only in severe weather conditions and very high sea states. In these cases, sonar detection is mostly ineffective due to the

high level of sea noise, so training is not essential. The considerable expense required for a rolling and pitching base is therefore not recommended for the small additional training realism which would be achieved.

APPEARANCE AND GROSS ENVIRONMENT REALISM

(U) The general appearance, size and arrangement of simulated shipboard spaces should be realistic when these factors affect trainee performances. If, due to space limitations, the operator is frequently jostled, interrupted or bumped while making fine adjustments, this condition should be duplicated in the trainer. If operators communicate with each other directly, the spacing and arrangement of work stations should be the same in the trainer.

(U) Of great importance in the SQS-26 Sonar Trainer is the ambient lighting and console lighting conditions. Trainees must learn to operate in a darkened room when switches, knobs, and labels are not visible.

(U) The exact location of controls on the simulated consoles is important because the operator must identify the control by its location on the panel. All knobs, screw heads and other projections on the console should be duplicated because they serve as location cues for the operator. Dummy knobs and indicators for non-operational functions should be provided for realistic appearance. They should be illuminated in the same manner as the operational equipment.

INDICATOR AND CONTROL REALISM

(U) The various knobs, switches, handwheels, joysticks and other controls should be closely simulated in the trainer. In addition to the importance of proper location as mentioned previously, trainees should learn the shape, feel and dynamic characteristics of each control. Controls with break out forces, detents, spring loadings, and friction should be accurately simulated since operators learn to expect these characteristics after frequent and repeated use (over-learned responses). If these characteristics are not provided in the trainer, trainees moving from the trainer to the operational equipment will have to relearn the feel of the controls. Operators returning to the trainer for refresher or advanced training will be disturbed by a different control feel, and must adjust their muscular response to the trainer controls. They will also need to make a visual check to assure themselves that they have used the correct control. If the control feel is identical or nearly so, the correct feel serves as a cue to reassure the operator that he has manipulated the correct control without the need for visual verification. In the darkened sonar room, this can be very important.

(U) Indicator and warning lights and digital readouts should be realistic also. Although dissimilar indicators and lights will probably have little effect on actual training, they will tend to interrupt the trainees realism "set". Each time a non-standard display is observed it will remind the trainee that he is in the trainer and not on real equipment.

CRT DISPLAY REALISM

(U) On the SQS-26 Sonar System, the various CRT's are the primary displays. The entire acceptance and attitude of the trainees toward the value of

practice in the trainer will depend significantly on the realistic appearance of these displays.

(U) The significant features involved in realism on these CRT displays are the magnitude and appearance of background noise and its relation to ocean conditions; the appearance, frequency of appearance, intensity, and ping-to-ping correlation of contacts; and the distinguishing characteristics of target submarine contacts.

BACKGROUND NOISE

(U) Noise in the SQS-26 Sonar is due to system noise, ocean noise, and reverberations. Such noise will be realistic if the magnitude and frequency on the various channels correlate with the basic causes in the system and real ocean. For example, noise should increase in intensity with higher sea states. Noise should increase when echoes return from the bottom and from the convergence zone. Noise components should vary randomly from ping to ping and should change when various switches are activated on the consoles. The biological factor should be present at some times and not at others.

(U) System noise should also appear and form persistent spokes masking entire bearings as in the operational equipment.

FALSE CONTACTS

(U) For good training conditions, two kinds of false contact should be provided in the trainer. The first kind should appear at random locations on the CRT and be controlled by the computer. The rate of appearance should be controlled by the instructor so that he can increase or decrease frequency to control problem difficulty.

(U) The second kind should have the same appearance but should be under complete control of the instructor. The instructor should be able to select one of several types, position the echo in X and Y, insert, and remove it. These false contact echoes should have the same shape, brightness, size, and other characteristics as contacts in the actual ocean. They should represent echoes from pinnacles, whales, kelpbeds, and schools of fish. These false contacts provide a definite effect on problem realism by representing actual false contacts as seen in the operational setting and also assuring that every contact presented is not a target contact.

SUBMARINE CONTACTS

(U) Echoes from target submarines should appear on the displays with all the characteristics of real submarine echoes in the actual ocean. They should appear and fade as do real submarine echoes, have similar signal-to-noise ratios, and move in a realistic manner. They should be controlled in depth, and both depth and movement should take advantage of BT layer conditions. Training will be enhanced by having realistic submarine contacts and false contacts because trainees must then learn to differentiate between them. At present, these cues are: ping-to-ping correlation, presence of range rate

(doppler), presence of an audio return, submerged depth, and realistic motion. The various types of false contacts and submarine targets will provide effective search, track, and classification training for SQS-26 Sonar operators.

WAKES

(U) Submarine and support unit wakes should be provided for realism, since submarines use wakes as countermeasures. In multiunit problems, support unit wakes may hinder tracking and increase difficulty in maintaining contact. These wakes should appear realistically and persist as in the actual ocean.

AUDIO REALISM

(U) In the SQS-26 Sonar System, the audio channel serves a limited purpose only. An audio signal should be provided but the sound may be a rough approximation only. All three operators use headsets and listen, but they do not attempt to analyze the audio signal for classification information as on high-frequency systems. Whether such clues as "metallic", "mushy", "echo quality", and "echo strength" are actually present is subject to question and no attempt is made by operators to use them. Therefore the audio signal may be a rough approximation with little degradation in training effect.

(U) Audio at the DIMUS channel may become more important as the fleet gets more experience with this equipment. Currently, however, it would appear satisfactory to vary the volume of the audio for bearing localization and not attempt to simulate machinery or screw noise. The increase in volume should vary with range and gradually fade into the noise at ranges which may be controlled by the instructor or implementation of the math model.

SECTION XII

CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

SCOPE OF THE HUMAN FACTORS STUDY

(U) The primary purpose of the Human Factors study was to investigate the need and to verify the desireability of adding an SQS-26BX capability to the existing 14A2A ASW Team Trainer. To provide a basis for decisions, the operator tasks required to operate the SQS-26 Sonar System in a tactical environment were analyzed to the extent that data and knowledge were available. First hand knowledge of the SQS-26BX system in the at-sea environment was found to be very limited at present. This is attributed to the early stage of development of the system and to lack of experience in actual at-sea conditions with ships equipped with SQS-26BX Sonar.

(U) The conclusions drawn from the analysis and study to date must be considered tentative pending further verification of the equipment at sea, and its use in the tactical environment.

(U) The overall conclusion made on the basis of this study is that there is a definite need to add an AN/SQS-26 Sonar training capability to the Surface Ship ASW Attack Trainer, Device 14A2A. The original assumption that such a capability is necessary is verified as a result of the following conclusions.

CONCLUSIONS

(U) The SQS-26BX Sonar is a very complex long-range detection system as compared to previous systems. The detection of targets at these very long ranges require new tactical procedures to capitalize on this capability. These tactics will dictate the type of operator activity and training required and the design of needed shore based trainers.

(U) The new tactics suggested above have not yet been completely developed and tested by the fleet. Neither has the capability of the SQS-26BX been fully explored and verified in actual at-sea conditions. Consequently the training exercises and design of a trainer must be based on various assumptions about tactics which are only probable or highly likely. It is concluded that a flexible approach is necessary so that a variety of tactical exercises can be accommodated.

(U) The task analysis of operator activities involved in the operation of the SQS-26 Sonar and the subsequent study of the tasks indicate that operators' duties will be complex, difficult and will require considerable coordination. It is concluded that the monitoring, decision making, procedure-following, and communication tasks involved in operating the SQS-26 Sonar will require extensive practice for effective operation of the system.

(U) It is concluded that training in the use and operation of the SQS-26 Sonar System is necessary in four phases.

1. Individual operator training in use of the consoles and interpretation of displays.

2. Sonar subteam training to train operators and supervisor to work together as a team.

3. Own Ship ASW team training to provide training exercises where the SQS-26 team must function and coordinate action with the remainder of the ASW team on own-ship.

4. SAU training where the SQS-26-equipped ship practices the ASW problem as part of a SAU group.

(U) Although part of this necessary training can and must be conducted at sea, it is concluded that the at-sea training will not be sufficient for maintaining the desired high skill level of operators. This conclusion arises from the fact that the ship may spend insufficient time in waters where conditions are favorable for practice in the various modes of operation. For example, few ocean areas are suitable for obtaining echoes in the bottom bounce mode, and the ship's time in these waters may be limited. Similarly, the ship may only occasionally be in waters suitable for convergence zone practice. Still another problem is the usual difficulty in obtaining operational submarines for practice in detecting live targets. All these factors indicate that at-sea training in all modes of operation will be restricted.

(U) It is concluded that the crew will not be able to practice the procedures and communications necessary to maintain a high degree of skill in all modes of SQS-26 operation at sea. This conclusion indicates the need for shorebased training where all modes can be provided so that monitoring, operating, procedural and communications skills, can be practiced.

(U) To provide training in all modes of operation of the SQS-26BX Sonar, both the depressed (Uni) channel and the surface duct (Omni) channel transmission simulations must be included. The use of these channels in various tactical exercises requires that all four operator consoles be simulated. It is concluded that a complete simulation of the SQS-26BX Sonar is necessary for effective training.

(U) Realistic simulation of the four operator consoles and the sonar displays is necessary for the required phases of training. Realistic and high fidelity simulation of the video is particularly important while the audio simulation may be of comparatively low quality. The extensive processing of sonar returns in the SQS-26BX system permits the possibility of developing electronically generated video displays with sufficient fidelity for most training purposes. If it turns out that still higher fidelity is needed for selected training requirements such as classification training, the use of high fidelity taped returns introduced into actual equipment or other high fidelity techniques will be necessary.

(U) This kind of training and training equipment may be needed in addition to the proposed solution recommended in this study.

(U) Sonar operator training and sonar team training is necessary in addition to the practice and training with the ASW team and SAU group. For better utilization of the trainer, for more flexible administration of the training

program and for better cost effectiveness, it is concluded that one facility can and should be used for almost all phases of SQS-26 Sonar training. This requires that the facility be designed to function in an independent mode of operation as well as with the current 14A2A ASW team training facility.

(U) The use of one facility for both an independent mode and with the 14A2A Trainer requires that two Instructors Consoles be provided. While the use of one console station is possible, it would cause interference with the operation of the 14A2A with a SQS-23 equipped ship and would be less effective and awkward to use in the independent mode.

(U) The use of a digital computer to generate problems and control the trainer permits the acquisition of large amounts of operator performance data. These data can be processed into various performance measures to indicate individual and team skills. The objective measures and scores from many individuals and teams can be combined and performance standards can be generated for comparison.

(U) It is concluded that the digital computer can and should be used for the collection of performance data and the development of fleet performance standards of operation of the SQS-26 Sonar System.

RECOMMENDATIONS

(U) The following is a list of recommendations:

1. A comprehensive SQS-26 Sonar Trainer should be added to the 14A2A ASW team training facility. This capability should include both the depressed and surface duct channel simulation and all four operator consoles.

2. The SQS-26 Sonar Trainer should be designed to operate in an independent mode for individual operator and sonar team training and in a joint mode with the 14A2A Trainer for ASW team and SAU training.

3. All of the displays and controls on the four operator consoles should be provided in the trainer with minor exceptions.

4. The video signals provided on the displays should be high fidelity simulations while the audio signal may be quite low.

5. Two separate instructor consoles should be provided, one for use in the independent mode and one for use with the current instructors console in the joint mode.

6. A comprehensive performance evaluation system should be developed with the specific measurement parameters to be determined when actual data is available.

APPENDIX A

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

CONTROLS AND INDICATORS

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Prepared by:

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CONTROLS AND INDICATORS OF A-SCAN CONSOLE, UNIT 1

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
<u>Top Control Panel</u>				
HORIZONTAL RANGE KILOYARDS	Dial	Off	Indicates horizontal range to target in kiloyards as computed by fire control (dial illuminates when fire control is transmitting data).	Dummy (For appearance only)
TARGET DEPTH FEET	Dial	Off	Indicates target depth in feet set in by fire control (dial illuminated when I(RA) lamp is lighted).	Dummy
TARGET DEPTH DISPLAY	CRT Screen	On	Displays returns from sound paths in BB mode. Setting cursors provides incremental range required to solve for target depth. Used as aid in classification.	[x]Oper. Trng. ([x]Operational Component required for training)
DEEP SOUND VELOCITY	Knob	4600-5100 Any	Select and set deep sound velocity for accurate ranges.	Oper. Trng.
TARGET DEPTH CRT INTENSITY	Rotary Control	Variable	Controls target depth display intensity.	Oper. Trng.
TARGET DEPTH MANUAL ERASE	Pushbutton	Off	Permits operator to erase target depth display instantly.	Oper. Trng.
A-SCAN CRT INTENSITY	Rotary	Variable Control	Controls intensity of A-Scan CRT.	Oper. Trng.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
<u>Top Control Panel</u> (Continued)				
A-SCAN CRT CONTROL	Rotary Control	Variable	Controls contrast of A-Scan CRT.	Oper. Trng.
A-SCAN CRT STORAGE TIME	Rotary Control	Variable	Controls display storage time of return on A-Scan CRT.	Oper. Trng.
A-SCAN CRT MANUAL ERASE	Pushbutton	Off	Permits operator to erase entire A-Scan CRT instantly.	Oper. Trng.
<u>Center Control Panel</u>				
SEARCH-TRACK	Pushbutton lamps	SEARCH	Selects and indicates search or track interval.	Oper. Trng.
ON TARGET	Pushbutton lamp	Off	Selects and indicates on target and informs FCS that sonar has good target tracking information.	Oper. Trng.
AIDED TRACK AVAIL	Lamp	Off	Indicates aided tracking information is available from fire control.	Oper. Trng.
AIDED TRACK	Pushbutton lamp	Off	Selects and indicates acceptance of aided tracking information from fire control.	Oper. Trng.
POS KEEP	Pushbutton lamp	Off	Selects and indicates acceptance of position keeping information from fire control to aid in regaining a lost target (operable only in search mode).	Oper. Trng.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
<u>Center Control Panel</u> (Continued)				
ODT, RDT, BB TRACK, BB, ODT, CZ	Pushbutton lamps	1 - On 4 - Off	Selects and indicates sonar operating modes.	Oper. Trng.
SSI AIDED TRACK	Lamp	Off	Indicates that Unit 3 has assumed tracking control and is supplying rate aided track based on target range rate for range only.	Oper. Trng.
SSI	Lamp	Off	Indicates that Unit 3 has assumed tracking control.	Oper. Trng.
RECYCLE	Pushbutton lamp	On	Selects and indicates (light off) return to flyback aborting receive interval. Also used with a mode switch to change operating mode during transmit interval.	Oper. Trng.
STAB OFF	Lamp	Off	Indicates no stabilization inputs to sonar.	*Malf. Trn.
DMho OFF	Lamp	Off	Indicates no Own-Ship speed input.	Malf. Trn.

*Required for malfunction training. May be dummy only if malfunctions will not be inserted by instructors.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Center Control Panel (Continued)				
XMTR ON	Pushbutton lamps	On	XMTR ON position routes power to transmitter time-delay circuit. Lamp indicates power routed to transmitter and transmitter door interlocks closed.	Oper. Trng.
SYSTEM POWER CABINET INTLK	Pushbutton lamps	On	SYSTEM POWER position selects and indicates system power on. CABINET INTLK position indicates A-scan cabinet interlocks are properly closed.	Oper. Trng.
SYSTEM OV HEAT CABINET OV HEAT	Pushbutton lamps	Off	Indicates by light and buzzer that a cabinet is overheated. Push-button turns off buzzer.	Malf. Trn.
Console Panel				
A-Scan Display	CRT Screen	ON	Displays 12 CP signal channels, 12 CW signal channels, and 2 OR signal channels. Each 12 traces denotes a 10-degree bearing increment providing a total 120-degree sector display centered a about a selected sector center. Display also provides six ping history. OR traces provide range information, one for CP signals and one for CW signals	Oper. Trn.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Console Panel (Continued)				
BB/CZ SELECTOR CENTER	Counter (digital readout)	0 to 360 -any-	Indicates center bearing of 120-degree receiving beam pattern.	Oper Trn.
B-Scan AUDIO	Pushbutton (momentary) lamp	Off	Selects and indicates monitoring of B-Scan audio.	Oper. Trn.
FM PRN	Pushbutton lamps	FM	Selects and indicates coded portion of BB or CZ transmission signal.	Oper. Trn.
NOTCH IN-NOTCH OUT	Pushbutton lamps	NOTCH OUT	NOTCH IN position selects and indicates receiver processing against reverberation for slow target (6 knots or below) detection. NOTCH OUT position indicates that receiver processing against reverberation not in use.	Oper. Trn.
SECT TRAIN-SECT FREEZE	Pushbutton lamps	SECT FREEZE	SECT TRAIN position selects and indicates (in conjuction with Cursor Control) a change in sector center bearing. (In Track mode, SECT TRAIN position in automatically selected). SECT FREEZE position indicates transmission and reception are held at a fixed bearing sector.	Oper. Trn.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
MAX RANGE K YDS	Counter (digital readout)	10 to 99	Indicates maximum sound range displayed on A-scan.	Oper. Trn.
TILT ANGLE	Selector switch	0, 5, 10, 15, 20, 30, 42 any	Selects nominal transmitting and receiving depression angle in degrees for BB and CZ modes and provides information to bottom bounce range computing circuits when ZONE RANGE switch is in AUTO position.	Oper. Trn.
ZONE RANGE	Pushbutton lamps	AUTO	AUTO position selects and indicates automatic BB mode range sweep calculations. MAN position selects and indicates manual BB or CZ range sweep.	Oper. Trn.
ZONE WIDTH	Pushbutton lamps	20 KYD	Selects and indicates zone width of A-scan display for BB and CZ modes.	Oper. Trn.
MANUAL RANGE	Selector switch	0 to 90 any	Selects start of A-scan displayed zone (minimum range) in kiloyards.	Oper. Trn.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
MIN RANGE K YDS	Counter (digital readout)	0 to 99 any	Indicates minimum sound range in kiloyards.	Oper. Trn.
DEPTH MAN/ AUTO	Pushbutton lamps	DEPTH AUTO	Select depth indication for manual switch position or auto from fathometer.	Oper. Trn.
CURSOR ON/OFF	Pushbutton lamps	Off	Make cursor visible continuously.	Oper. Trn.
AUDIO GAIN	Knob	Variable	Controls audio sound level.	Oper. Trn.
OR THRESHOLD	Knob	Variable	Controls signal intensity of OR channels (CP and CW).	Oper. Trn.
SOUND RANGE KILOYARDS	Counter (digital readout)	0 to 99 - any -	Indicates range value in kilo-yards.	Oper. Trn.
BEARING	Counter (digital readout)	0 to 360 - any -	Indicates bearing value in degrees.	Oper. Trn.
TRUE-REL	Lamps	TRUE	TRUE position indicates own ship course from UBFC Switch-board; REL position indicates own ship course inputs are missing or electrically zeroed in UBFC Switchboard.	Oper. Trn.

Controls and Indicators of A-Scan Console; Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
FREQUENCY CHANNEL	Selector switch	1, 2, 3 any	Selects system operating frequency in all modes except CZ.	Oper. Trn.
BOTTOM DEPTH FATH	Selector switch	500 to 4, 000 - any -	Selects bottom depth input for bottom bounce computations. (DEPTH MAN/DEPTH AUTO switch in DEPTH MAN position.)	Oper. Trn.
Shelf				
TARGET DEPTH LEFT CURSOR RIGHT CURSOR	Handwheel Handwheel	Variable	LEFT CURSOR handwheel controls left cursor on Target Depth CRT. RIGHT CURSOR handwheel controls right cursor on Target Depth CRT. (Cursors are used to obtain incremental range I(Ra).)	Oper. Trn.
I(RA) AVAIL	Pushbutton lamp	Off	Selects and indicates good incremental range information is available to FCS from Target Depth controls.	Dummy
CURSOR CONTROL PUSH TO TRAIN (NDT)	Joystick Pushbutton	Variable centered	Controls cursor position. Pushbutton on top of joystick initiates New Data Time (NDT).	Oper. Trn.

Controls and Indicators of A-Scan Console, Unit 1 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Shelf (Continued)				
AUDIO/RECORDER BEAM SELECTOR	Selector switch	LEFT, CENTER, RIGHT	Selects four related beams of twelve receiving beams for audio presentation and application to Unit 3 echo trap circuits for presentation on GI display.	Oper. Trn
STBY-TRAP	Pushbutton lamps	OFF or STBY	STBY position indicates that Unit 3 operator has selected standby. TRAP position selects and indicates trap operation which attempts to store target signal in Unit 3 echo trap circuit.	Oper. Trn.
Illumination	Knob	Variable	Controls brightness of Besel Lamps on all consoles.	Oper. Trn.

CONTROLS AND INDICATORS OF B-SCAN CONSOLE, UNIT 2

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Top Control Panel				
Planned Position Indicator (PPI) (No panel designation)	CRT	On	Displays 360-degree area around own ship.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Top Control Panel (Continued)				
Shallow Sound Velocity	Selector knob	4800-5100 any	Select Shallow Sound Velocity for inserting into System to obtain accurate ranging.	Oper. Trn.
PPI Intensity	Knob	Variable	Adjust intensity of PPI CRT.	Oper. Trn.
PPI Cursor Intensity	Knob	Variable	Adjust intensity of PPI cursor.	Oper. Trn.
B-Scan Intensity	Knob	Variable	Adjust intensity of B-Scan CRT.	Oper. Trn.
B-Scan Contrast	Knob	Variable	Adjust contrast of B-Scan CRT.	Oper. Trn.
B-Scan Storage Time	Knob	Variable	Adjust storage time of signal returns on B-Scan CRT.	Oper. Trn.
B-Scan Manual Erase	Pushbutton	Off	Permits operator to erase all signals on B-Scan CRT instantly.	Oper. Trn.
SYSTEM INTLK-CABINET INTLK	Lamps	On On	SYSTEM INTLK position indicates unregulated 28V DC is on, transmitter ±10V DC power supply is on, and heat-exchanger fans are on. CABINET INTLK position indicates B-scan cabinet interlocks are properly closed.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Top Control Panel (Continued)				
SYSTEM OV HEAT CABINET OV HEAT	Lamps	Off Off	Lights when a cabinet has reached an overheated condition.	Malf. Trn.
XMTR ON	Lamp	On	Indicates transmitter time delay circuits on and transmitter door interlocks closed.	Oper. Trn.
STAB OFF	Lamp	On, off	Indicates no stabilization inputs to sonar.	Malf. Trn.
DMho OFF	Lamp	On, off	Indicates no own ship speed inputs.	Malf. Trn.
RECYCLE	Pushbutton lamp	Off	Selects and indicates (light off) return to flyback, aborting receive interval.	Oper. Trn.
SSI	Lamp	Off	Indicates Unit 3 has assumed tracking control.	Oper. Trn.
SSI AIDED TRACK	Lamp	Off	Indicates Unit 3 has assumed tracking control and is supplying rate aided track based on target range rate for range only.	Oper. Trn.
ODT, RDT, BB TRACK, BB/ODT, CZ	Lamps	1 - on 4 - off	Indicates echo-ranging mode.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Top Control Panel (Continued)				
SEARCH-TRACK	Pushbutton lamps	SEARCH	Selects and indicates SEARCH or TRACK interval.	Oper. Trn.
ON TARGET	Pushbutton lamps	Off	Selects and indicates on target and informs fire control that sonar has good target tracking information.	Oper. Trn.
AIDED TRACK AVAIL	Lamp	Off	Indicates aided track information is available from fire control.	Oper. Trn.
AIDED TRACK	Pushbutton lamp	Off	Selects and indicates acceptance of aided tracking information from fire control.	Oper. Trn.
POS KEEP	Pushbutton lamp	Off	Selects and indicates acceptance of position keeping information from fire control for regaining a lost target (operable only in SEARCH mode).	Oper. Trn.
Console Panel				
B-scan (No panel designation)	CRT	On	Displays 72 omni receiver channels during range interval corresponding to setting of Range Scale switch.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Console Panel (Continued)				
RDT SECTOR CENTER	Counter (digital readout)	0 to 360 any	Indicates center bearing in degrees of RDT receiving and transmitting beam pattern.	Oper. Trn.
RDT SECTOR WIDTH	Selector switch	40, 80, 120, 160, 200, 240, 280, 320, 360 -any-	Selects sector width of RDT transmission beam pattern.	Oper. Trn.
SECT TRAIN-SECT FREEZE	Pushbutton lamps	SECT FREEZE	SECT TRAIN position selects and indicates (in conjunction with Cursor Control) a change in sector center bearing in RDT mode. (In track mode, SECT TRAIN position is automatically selected.) SECT FREEZE position indicates transmission and reception are held at a fixed bearing sector.	Oper. Trn.
PULSE LENGTH MS	Selector switch	30, 100, 300, 1000 any	Selects transmission pulse length in ODT or RDT modes. (1000 MS selected in ODT mode only.)	Oper. Trns.
RANGE SCALE KILOYARDS	Selector switch	2.5, 5.0, 10, 15, 25, 50, LISTEN, HAND KEY any	Select range sweep length to be displayed on B-scan display. LISTEN and HAND-KEY position used in conjunction with HAND-KEY pushbutton to transmit and receive underwater communications.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
<u>Console Panel</u> (Continued)				
XMTR Power Level	Selector switch	0 - 10	Reduce power output under conditions of high reverberation.	Oper. Trn.
SOUND RANGE KILOYARDS	Counter (digital readout)	50.00 any	Indicates range value in kiloyards.	Oper. Trn.
BEARING	Counter (digital readout)	0 to 360 any	Indicates bearing value in degrees.	Oper. Trn.
CURSOR ON CURSOR OFF	Pushbutton lamps	OFF	CURSOR ON position selects and indicates continuous cursor printing. CURSOR OFF position selects and indicates cursor printing during NDT only.	Oper. Trn.
TRUE REL	Lamps	TRUE	TRUE position indicates Own Ship course from UBFC Switchboard. REL position indicates Own Ship course inputs are missing or electrically zeroed at UBFC Switchboard.	Malf. Trn.
A-SCAN AUDIO	Pushbutton (momentary) lamp	OFF	Selects and indicates monitoring of A-Scan audio.	Oper. Trn.

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	3 -Initial Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
PPI GAIN	Handknob	Variable	Controls PPI video gain.	Oper. Trn.
AUDIO GAIN	Handknob	Variable	Controls audio sound level.	Oper. Trn.
PPI SUM/DIFF	Pushbutton lamps	SUM	Select sum or diff display brightening on PPI CRT.	Oper. Trn.
SINGLE AUDIO MULTI AUDIO	Pushbutton switch	MULTI AUDIO	SINGLE AUDIO provides on 8 1/2° wide beam manually. MULTI AUDIO provides a 40° wide beam binaurally.	Oper. Trn.
NOTCH IN NOTCH OUT	Pushbutton switch	NOTCH OUT	NOTCH IN inserts a filter to reject reverberation for improved detection of high doppler targets.	Oper. Trn.
Shelf				
CURSOR CONTROL PUSH TO TRAIN (NDT)	Joystick Pushbutton	Variable	Controls cursor position on B-scan and PPI CRT's. Pushbutton on top of joystick initiates New Data Time (NDT).	Oper. Trn.
Handkey	Pushbutton	Off	Key for handkey transmission for communication.	Dummy

Controls and Indicators of B-Scan Console, Unit 2 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Shelf (Continued)				
Illumination	Knob	Variable	Controls edgelighting brightness on all consoles.	Oper. Trn.

CONTROLS AND INDICATORS OF TRACKING CONSOLE, UNIT 3

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel				
SYSTEM INTLK	Lamps	On	SYSTEM INTLK position indicates unregulated 28V DC is on, transmitter ±10V DC power supply is on, and heat-exchanger fans are on. CABINET INTLK position indicates Unit 3 interlocks are closed.	Oper. Trn.
SYSTEM OV HEAT	Lamps	Off	Same as A-Scan.	Malf. Trn.
SSI OFF	Pushbutton lamp	On	Selects and indicates release of SSI or SSI AIDED TRACK.	Oper. Trn.
STAB OFF DMho OFF	Lamps	Off	STAB OFF position indicates stabilization inputs to sonar are not being supplied from FCS. DMho OFF position indicates own ship speed is not being supplied from FCS.	Malf. Trn.

Controls and Indicators of Tracking Console, Unit 3 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
RECYCLE	Pushbutton lamp	On	Selects and indicates return to flyback aborting receive interval in SSI or SSI Aided Track	Oper. Trn.
SSI	Pushbutton lamp	Off	Selects and indicates Omni or Uni SSI for system (cursor control shifted from operating console to Unit 3 console).	Oper. Trn.
SSI AIDED TRACK	Pushbutton lamp	Off	Selects automatic aided track in range only.	Oper. Trn.
ODT, RDT, BB TRACK, BB/ODT, CZ	Lamps	1 - on 4 - off	Indicates which echo-ranging mode system is in.	Oper. Trn.
SEARCH-TRACK	Lamps	Search	Indicates whether operating console is in a SEARCH or TRACK interval.	Oper. Trn.
ON TARGET	Lamp	Off	Indicates smooth and accurate operating console tracking is available to fire control.	Oper. Trn.
AIDED TRACK AVAIL	Lamp	Off	Indicates aided tracking information is available from fire control.	Oper. Trn.

Controls and Indicators of Tracking Console, Unit 3 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Control Panel (Continued)				
AIDED TRACK	Lamp	Off	Indicates operating console operator accepted aided track from fire control.	Oper. Trn.
POS KEEP	Lamp	Off	Indicates operating console accepted position keep data from fire control.	Oper. Trn.
Console Panel				
SECTOR SCAN	CRT	On	Displays a range increment of ±100° yards and a bearing increment of 5 degrees centered about selected operating console cursor position.	Oper Trn.
GRAPHIC INDICATOR	CRT	On	Displays a range increment of ±100° yards centered about selected operating console cursor. Used for determining range rate. During echo trap operation, possible contacts are redisplayed on the range rate display for doppler classification purposes.	Oper. Trn.
A SCAN B SCAN	Pushbutton lamps	A-SCAN	Selects and indicates which operating console input is used in Unit 3.	Oper. Trn.

Controls and Indicators of Tracking Console, Unit 3 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
<u>Console Panel</u> (Continued)				
FCS RANGE RATE	Pushbutton lamp	Off	Selects and indicates that accurate range rate information is being generated for fire control use (not presently used).	
AUDIO GAIN	Handknob	Variable	Controls audio sound level.	Oper. Trn.
SSI VIDEO GAIN	Handknob	Variable	Controls gain of video signal applied to SSI CRT.	Oper. Trn.
GI VIDEO GAIN	Handknob	Variable	Controls gain of video signal applied to GI display CRT.	Oper. Trn.
TRUE-REL	Lamps	TRUE	TRUE position indicates own ship course is being supplied to sonar from UBFC Switchboard; REL position indicates own ship course inputs are missing or electrically zeroed at UBFC Switchboard.	
SOUND RANGE KILOYARDS	Counter (digital readout)	0 - 99.99 any	Indicate range value in kiloyards of SSI display cursor.	Oper. Trn.
BEARING	Counter (digital readout)	0 to 360	Indicates bearing value in degrees of SSI display cursor.	Oper. Trn.

Controls and Indicators of Tracking Console, Unit 3 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Console Panel (Continued)				
CRT Controls				
SSI Intensity	Knob	Variable	Controls SSI Sweep Intensity.	Oper. Trn.
SSI Focus	Knob	Variable	Controls SSI Sweep Focus.	Oper. Trn.
SSI Cursor	Knob	Variable	Controls SSI Cursor Intensity.	Oper. Trn.
B Range High	Screw	-	Maintenance Adjustment.	
B Range Low	Screw	-	Maintenance Adjustment.	
Video Trim	Screw	-	Maintenance Adjustment.	
Cursor Size	Screw	-	Maintenance Adjustment.	
CRT Controls				
GI Brightness	Knob	Variable	Controls brightness of GI display.	Oper. Trn.
Focus	Knob	Variable	Controls Focusing of GI display.	Oper. Trn.
B Bearing High	Screw	-	Maintenance Adjustment.	
B Bearing Low	Screw	-	Maintenance Adjustment.	
Test/Operate	Toggle	Operate	Test position provides coarse check on calibration.	

Controls and Indicators of Tracking Console, Unit 3 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Shelf				
CURSOR CONTROL PUSH TO TRAIN (NDT)	Joystick Pushbutton	Variable	Controls cursor position on Sector Scan Indicator, pushbutton on top of joystick initiates New Data Time (NDT).	Oper. Trn.
RECORDER BEAM SELECTOR	Selector switch	LEFT OUTER, LEFT INNER, RIGHT INNER, RIGHT OUTER	Selects one of the four beams recorded in echo trap circuits. Displayed on Graphic Indicator.	Oper. Trn.
STBY-TRAP	Pushbutton switch, lamps	STBY	TRAP position indicates A-scan operator has selected echo trap operation. STBY position selects and indicates the return of echo trap circuit to standby.	Oper. Trn.
RANGE RATE	Handwheel	Variable	Generates, in conjunction with GI display, a range rate transmission to fire control (not presently used), or for direct use within sonar units during SSI Aided Track.	Oper. Trn.
RANGE RATE KNOTS	Counters (digital readout)	0 to -50 0 to +50 any	Indicates range rate. Two separate counters are used; one for opening (positive) and one for closing (negative) range rates.	Oper. Trn.

CONTROLS AND INDICATORS OF PASSIVE RECORDER, UNIT 4

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Shelf (Continued)				
SIGNAL BEARING	Handknob	0 to 360 any	Controls a 360-degree audio spectrum scan around own ship (synchronous transmissions to fire control are provided in bearing from this control).	Oper. Trn.
RECORDER	Toggle Switch	STANDBY	ON position starts recording on Azimuth Recorder.	Oper. Trn.
	Paper display	360-degrees & 7.5 minutes	Displays relative time-bearing plot with ships head (000-degrees) in center and 180-degrees on each edge. Each beam is sampled in succession and recorded as a mark; each trace across plot corresponding to a scan through 360-degrees.	Oper. Trn.
AUDIO GAIN	Handknob	Variable	Controls audio level	Oper. Trn.
ILLUMINATION	Knob	Variable	Controls illuminates of the recorder and panel.	Oper. Trn.
MARKING INTENSITY	Knob	Variable	Control recorder marking intensity.	Oper. Trn.

CONTROLS AND INDICATORS FOR TEST SET CONSOLE, UNIT 5

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Upper Control Panel				
TARGET BEARING	Handknob counter	0 to 360	Controls and indicates initial test target bearing in degrees.	Oper. Trn.
TARGET COURSE	Handknob counter	0 to 360	Controls and indicates fixed test target course in degrees.	Oper. Trn.
TARGET RANGE	Handknob counter	0 to 100, 000	Controls and indicates initial test target range in yards.	Oper. Trn.
TARGET SPEED	Handknob counter	0 to 30	Controls and indicates fixed test target speed in knots.	Oper. Trn.
DMho MAN-DMho AUTO	Pushbutton lamps	In, Out On, Off	DMho MAN position selects and indicates OWN SHIP SPEED handknob inputs. DMho AUTO position selects and indicates UBFC Switchboard inputs.	Oper. Trn.
OWN SHIPS SPEED	Handknob counter	0 to 99	Handknob controls value of own ships speed when DMho MAN-DMho AUTO is in DMho MAN position. Counter indicates own ships speed in knots.	Oper. Trn.
STANDBY-OPERATE	Pushbutton lamps	In, Out On, Off	STANDBY position selects and indicates standby condition for initial test target settings. OPERATE position selects and indicates condition for computer problem.	Oper. Trn.

Controls and Indicators for Test Set Console, Unit 5 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Lower Right Control Panel				
AUTO DOPPLER MAN DOPPLER	Toggle switch	Up, down	AUTO DOPPLER position selects automatic condition for computer to set total range rate for GI display. MAN DOPPLER position selects manual condition for system maintenance.	Dummy
KEY	Selector switch	INT, MARK EXT	EXT position selects a single test target signal. INT position selects a multiple test target echo. MARK position selects a condition for system maintenance.	Dummy
SIGNAL LEVEL DB (A+B)	A Selector switch	-50, -40 -30, -20, -10, 0, +10	Switches A and B (operating together) control level of test target signal; maximum attenuation (-60 db) is equivalent to a level of sea state zero.	Dummy
	B Selector switch	0 to 10		
MODE	Selector switch	STBY, ODT RDT, BB/ CZ, DIMUS, CW	STBY position selects standby condition and removes test target from all operating console CRT screens. ODT, RDT, BB/CZ, or DIMUS position selects B-scan, A-scan, or Azimuth Recorder, respectively, for insertion of a test target signal.	Oper. Trn.

Controls and Indicators for Test Set Console, Unit 5 (Continued)

1 -Component	2 -Type	Initial 3 -Indication	4 -Purpose	5 -Training
Lower Right Control Panel (Continued)				
MODE (Continued)			CW or FREQ CAL position selects CW or frequency calibration condition for use in system maintenance.	
MODE	Lamps	ODT RDT CZ BB	Indicates echo-ranging mode.	Dummy

APPENDIX B

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

DETAIL TASK LIST

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APPENDIX B

DETAIL TASK LIST

Block 1. Compute Settings and Predict Performance
- 1.0 Determine tactical orders
- 1.1 Obtain quartermaster log sheet data
- 1.2 Obtain and compute true wind speed
- 1.3 Obtain bathythermograph data
- 1.4 Obtain echo sounder, depth, and bottom data
- 1.5 Obtain surface salinity data
- 1.6 Compute sound velocities
- 1.7 Determine mode of operation
- 1.8 Determine equipment settings
- 1.9 Determine predicted performance

Block 2. Setup and Checkout Equipment
- 2.1 Energize all equipment
  - 2.1.1 Depress SYSTEM POWER switch, A-Scan Console
  - 2.1.2 Note SYSTEM POWER and CABINET INTLK lamps are lighted on A-Scan, B Scan and Tracking Consoles
  - 2.1.3 Note RECORDER display is lighted on passive console
  - 2.1.4 Note that panel lamps are lighted on the TEST SET console
- 2.2 Check equipment operation
  - 2.2.1 Check equipment for normal operating indications (See Appendix A)
  - 2.2.2 Note variations and place system in NORMAL
  - 2.2.3 Note non-normal and malfunction indications and report to Supervisor
  - 2.2.4 Supervisor determines course of action based on non-normal or malfunction reports
- 2.3 Make desired settings on equipment and initiate transmission program
  - 2.3.1 A-Scan console equipment settings
    - 2.3.1.1 Select (or check) DEPTH AUTO/DEPTH MAN switch
      - a. DEPTH AUTO if AN/UQN-1 is available
      - b. DEPTH MAN if AN/UQN is not available

2.3.1.2 Turn BOTTOM DEPTH-FATH knob to setting entered on checklist (Block 1)

2.3.1.3 Turn TILT ANGLE knob to checklist angle

- a. 20° for BB/ODT mode (normal)
- b. 0° for CZ mode (normal)

2.3.1.4 Turn DEEP SOUND VELOCITY knob to setting entered on checklist (Block 1)

2.3.1.5 Select (or check) AUTO/MAN switch position for ZONE RANGE

- a. AUTO - Min. and Max. range are read out automatically
- b. MANUAL - Requires positioning ZONE WIDTH switch and MANUAL RANGE knob

2.3.1.6 Turn MANUAL RANGE knob to minimum range entered on checklist (Block 1)

2.3.1.7 Select 10 KYD/20KYD per checklist (Block 2)

2.3.1.8 Set AUDIO RECORDER BEAM SELECT switch to CENTER

2.3.1.9 Adjust TARGET DEPTH, A-Scan CRT controls and illumination to desired level

2.3.1.10 Set FREQUENCY CHANNEL to checklist setting (Block 1)

2.3.2 B-Scan Console equipment settings

2.3.2.1 Set SHALLOW SOUND VELOCITY knob to checklist setting (Block 1)

2.3.2.2 Set RANGE SCALE - KILOYARDS per predicted surface channel range on checklist (Block 1)

2.3.2.3 Set RDT SECTOR WIDTH to appropriate setting

2.3.2.4 Set XMTR POWER LEVEL - DB to appropriate setting

2.3.2.5 Set PULSE LENGTH - MS to appropriate setting

2.3.2.6 Adjust CRT controls, PPI GAIN and illumination to desired level

2.3.3 Tracking Console equipment settings

2.3.3.1 Adjust VIDEO GAIN and CRT controls to desired levels

2.3.4 Passive Console equipment settings

2.3.4.1 Adjust illumination and marking intensity to desired level

2.3.4.2 Place RECORDER switch to ON

2.3.5 Initiate Mode Select on A-Scan Console
  2.3.5.1 Depress MODE switch and hold; note all lamps are lighted on A-Scan, B-Scan and Tracking Consoles. Release switch and note SELECTED MODE lamp remains lighted; others go off
2.3.6 Initiate transmission program on A-Scan Console; depress XMTR ON switch; note XMTR ON lamps are lighted on A-Scan and B-Scan Consoles

2.4 Insert simulated target on Test Set Console
  2.4.1 Set in simulated TARGET RANGE and BEARING (Based on predictions from Block 1)
  2.4.2 Select DMho MAN/AUTO and set in Own Ship Speed if necessary
  2.4.3 Select MODE, AUTO/MAN DOPPLER, KEY, and SIGNAL LEVEL
  2.4.4 Place STANDBY/OPERATE switch in OPERATE

2.5 Verify ranges and detection probability
  2.5.1 Determine and verify maximum range and detection probability in ODT and RDT mode on B-Scan Console by adjusting target range on Test Set Console
  2.5.2 Determine and verify maximum range and detection probability in CZ or BB mode on A-Scan Console by adjusting target range on Test Set Console
  2.5.3 Determine and verify SSI operation on Tracking Console
  2.5.4 Verify bearing detection on passive recorder

2.6 Remove simulated target and begin search
  2.6.1 Place STANDBY/OPERATE switch on Test Set Console in STANDBY
  2.6.2 Report sonar range predictions to bridge and CIC based on theory and data from Block 1

Block 3. Conduct Search

3.1 Conduct search in CZ mode (for ODT see 3.4)
  3.1.0 Check that CZ lamp, XMTR ON lamp, and SEARCH lamp are lighted
  3.1.1 Make specific equipment settings for CZ mode
  3.1.2 Select desired bearing
  3.1.3 Operator monitors A-Scan display for echoes
  3.1.4 Detect consistent echo on A-Scan display
  3.1.5 Supervisor monitors displays and settings and sees echo

3.2 Conduct search in BB/ODT mode (for ODT portion of search, see 3.4)
  3.2.0 Check that BB/ODT lamp, XMTR ON lamp, and SEARCH lamp are lighted
  3.2.1 Make specific equipment settings for BB/ODT mode
  3.2.2 Select desired bearing

3.2.3 Operator monitors A-Scan display for echoes
3.2.4 Operator detects consistent echo on A-Scan display
3.2.5 Supervisor monitors displays and settings and sees echo

3.3 Conduct search in BBT mode (Not ordinarily used in search mode)

3.4 Conduct search in ODT mode (includes ODT portion of BB/ODT and CZ mode except as noted)
3.4.0 Check that ODT lamp (or BB/ODT or CZ), XMTR ON lamp, and SEARCH lamp are lighted
3.4.1 Make specific equipment settings
3.4.2 Operator monitors multi-audio channels and B-Scan and PPI displays for echoes
3.4.3 Operator detects consistent echo on B-Scan or PPI display or on audio channel
3.4.4 Supervisor monitors displays and activity

3.5 Conduct search in RDT mode
3.5.0 Check that RDT lamp, XMTR ON lamp, and SEARCH lamp are lighted
3.5.1 Make specific equipment settings
3.5.2 Select desired sector center bearing
3.5.3 Operator monitors multi-audio channels and B-Scan and PPI displays for echoes
3.5.4 Operator detects consistent echo on B-Scan or PPI display or on audio channel
3.5.5 Supervisor monitors displays and activity

3.6 Observe indication on passive recorder
3.6.0 Check that recorder lamps are lighted and RECORDER switch is ON
3.6.1 Periodically observe recorder display for noise indication

Block 4. Contact Phase

4.1 Investigate Sonar contact in CZ mode
4.1.1 Supervisor informs Bridge and CIC of Sonar contact on 29 MC intercom system
4.1.2 A-Scan Operator positions cursor on echo and depresses TRACK button for track mode
4.1.3 Supervisor receives bearing clear or foul information from Bridge
4.1.3.1 If bearing foul, return to 3.1
4.1.3.2 If bearing clear, continue to 4.1.4
NOTE: Under non-standard conditions, Sonar Supervisor may receive information direct from CIC
4.1.4 A-Scan Operator positions cursor on successive returns and listens on audio channel
4.1.5 Tracking Console Operator depresses A-Scan switch and observes SSI and GI for echo

4.1.6 Tracking Console Operator verifies target on SSI when seen, and depresses SSI button to get control of cursor

4.1.7 Tracking Console Operator monitors Graphic indicator and determines range rate with hand wheel

4.1.8 On successive returns, Tracking Console Operator observes echo on SSI, positions cursor on echo, depresses NDT switch and operates hand wheel to obtain range rate

4.1.9 Tracking Console Operator notes consistent tracking on SSI and GI and depresses SSI AIDED TRACK button

4.1.10 A-Scan Operator continues to monitor A-Scan for other echoes and notes smooth tracking of cursor on contact

4.1.11 Supervisor observes tracking consistency on A-Scan, SSI and GI and receives verbal report from A-Scan and Tracking Console Operators

4.1.12 Supervisor determines contact is possible sub and requires further investigation and orders A-Scan Operator to go to ON TARGET

4.1.13 A-Scan Operator depresses ON-TARGET button

4.1 (ALTERNATE) Investigate contact in CZ mode (with echo trap)

4.1.0 A-Scan Operator detects echo on A-Scan display

4.1.1 A-Scan Operator checks with Tracking Console Operator to assure that console is in A-Scan and STBY-TRAP switch is in STBY

4.1.2 A-Scan Operator positions AUDIO/RECORDER BEAM SELECTOR switch to group of 4 beams containing the echo and calls out beam to Tracking Console Operator

4.1.3 Listen to echo on audio channel and adjust GAIN as necessary

4.1.4 Position cursor on expected echo range and bearing (same as 3.1)

4.1.5 On next return, depress STBY/TRAP switch to TRAP within 2.5 seconds of appearance of echo

4.1.6 Tracking Console Operator positions RECORDER BEAM SELECT to beam containing echo

4.1.7 Listen to echo on audio channel, adjusting AUDIO GAIN knob as necessary

4.1.8 Tracking Console Operator rotates RANGE RATE knob to vertically align echo and determine presence of doppler on GI Display

4.1.9 A-Scan Operator continues to monitor A-Scan for other echoes

4.1.10 After analysis, Tracking Console Operator depresses STBY/TRAP switch to return to STBY

4.1.11 Change settings of TILT ANGLE, ZONE WIDTH, MANUAL RANGE and FM/PRN if necessary to intensify return

4.1.12 Repeat 4.1.2 through 4.1.11 as often as necessary to indicate echo is a possible target

NOTE: Echo may not appear on each return due to ocean characteristics. Skill is required to adjust equipment to maximize detection probability and analyze echo.

4.1.13 Tracking Console Operator and A-Scan Operator communicate to Supervisor that echo is a possible submarine or definite non-submarine

4.1.14 Supervisor makes decision to go to TRACK to continue investigation, or to continue SEARCH

NOTE: End of alternate sequence

4.2 Investigate sonar contact in BB mode

4.2.1 Supervisor informs Bridge and CIC of sonar contact in BB mode on 29 MC intercom system

4.2.2 A-Scan Operator positions cursor on echo and depresses TRACK button

4.2.3 Supervisor receives bearing clear or foul information from Bridge

4.2.3.1 If bearing is foul, return to 3.2

4.2.3.2 If bearing is clear, continue to 4.2.4

NOTE: Under non-standard conditions Sonar may receive information from CIC.

4.2.4 A-Scan Operator positions cursor on successive returns and listens on audio channel

4.2.5 Tracking Console Operator depresses A-SCAN switch and observes SSI and GI for echo

4.2.6 Tracking Console Operator verifies target on SSI, when observed, and depresses SSI button to get control of cursor

4.2.7 Tracking Console Operator monitors GI and manipulates hand wheel to obtain range rate of echo

4.2.8 On successive returns, Tracking Console Operator observes echo on SSI and GI, positions cursor on echo, depresses NDT switch, and operates hand wheel to obtain range rate

4.2.9 Tracking Console Operator notes consistent tracking on SSI and GI and depresses SSI AIDED TRACK button

4.2.10 A-Scan Operator continues to monitor A-Scan for tracking on target, and monitors A-Scan for other echoes

4.2.11 Supervisor observes tracking consistency and receives verbal report from A-Scan and Tracking Console operators

4.2.12 Supervisor determines contact is possible sub, requests further investigation and orders ON TARGET
4.2.13 A-Scan Operator depresses ON TARGET button

4.2 (ALTERNATE) Investigate contact in BB mode (with echo trap)

4.2.0 Echo has been detected on A-Scan console in BB/ODT mode
4.2.1 Check with Tracking Console Operator to assure that console is in A-Scan and STBY/TRAP switch is in STBY
4.2.2 A-Scan Operator positions audio recorder BEAM SELECTOR switch to group of beams containing the echo (Left, Center or Right) and calls out beam to Tracking Console Operator
4.2.3 A-Scan Operator listens to audio channel and adjusts GAIN if necessary
4.2.4 Position cursor on expected range and bearing of echo as in 3.2
4.2.5 On next return, depress STBY/TRAP switch to TRAP within 2.5 seconds of appearance of echo
4.2.6 Tracking Console Operator positions recorder BEAM SELECT switch on beam with echo
4.2.7 Tracking Console Operator listens to audio channel, adjusting AUDIO GAIN if necessary
4.2.8 Tracking Console Operator rotates RANGE RATE knob to vertically align echo and determine presence of doppler
4.2.9 A-Scan Operator continues to monitor A-Scan for other echoes
4.2.10 After analysis, Tracking Console Operator returns STBY/TRAP switch to STBY
4.2.11 A-Scan Operator adjusts TILT ANGLE, ZONE WIDTH, MANUAL RANGE, FREQUENCY CHANNEL, and NOTCH IN/NOTCH OUT controls if necessary to intensify return
4.2.12 Repeat 4.2.2 through 4.2.11 as often as necessary to indicate echo is a possible target

NOTE: Echo may not appear on each return due to ocean characteristics. Skill is required to adjust equipment and analyze echo.

4.2.13 Tracking Console Operator and A-Scan Operator communicate opinions to Supervisor regarding echo
4.2.14 Supervisor makes decision to go to TRACK or resume search as in 3.2

NOTE: End of alternate sequence

4.3 Investigate echo in BB track mode (not used)

4.4 Contact phase in ODT mode

NOTE: Doctrine may require switching to RDT mode with narrow sector immediately (See 4.5)

4.4.0 Consistent echo has been detected on B-Scan or PPI displays on B-Scan Console

4.4.1 Supervisor informs Bridge and CIC of sonar contact in ODT mode on 29 MC intercom system and receives Bearing CLEAR information. If bearing is FOUL, resume search (See 3.4)

4.4.2 B-Scan Operator positions cursor on echo, observes correlation of echo range and bearing on B-Scan and PPI display, and depresses TRACK mode switch

4.4.3 B-Scan Operator switches to single beam. Listens to echo in audio channel and adjusts AUDIO GAIN as necessary

4.4.4 A-Scan Operator may elect to depress B-Scan audio and monitor B-Scan audio channel

4.4.5 Tracking Console Operator depresses B-Scan switch to connect tracking console to B-Scan console

4.4.6 Tracking Console Operator verifies valid target and depresses SSI button. Observes GI display and manipulates hand wheel to obtain doppler indication

4.4.7 B-Scan Operator and Supervisor observe 3-ping history on B-Scan display

4.4.8 Change settings on RANGE SCALE KILOYARDS, XMTR POWER LEVEL-DB, PULSE LENGTH, NOTCH IN/NOTCH OUT, PPI SUM/PPI DIFF as necessary to intensify the echo and get good detection

4.4.9 Supervisor also monitors B-Scan, PPI, and GI displays and repeat 4.4.2 through 4.4.8 as necessary

4.4.10 B-Scan Operator, Tracking Console Operator, and A-Scan Operator communicate opinions regarding contact to Supervisor

4.4.11 Supervisor makes initial classification as definite NON-SUBMARINE, continue search as in 3.4. If POSSIBLE SUBMARINE, Supervisor orders A-Scan Operator to depress ON TARGET switch

4.5 Contact phase in RDT mode

4.5.0 Consistent echo has been observed on B-Scan or PPI in ODT or RDT search mode

NOTE: If in ODT, A-Scan Operator must change mode to RDT.

4.5.1 Supervisor informs Bridge and CIC of sonar contact in RDT (or ODT) on 29 MC intercom and receives BEARING CLEAR or FOUL information. If bearing is FOUL, resume search (See 3.5). If bearing is CLEAR, proceed to 4.5.2

4.5.2 B-Scan Operator switches SECTOR WIDTH to 40°, MULTI-AUDIO switch to SINGLE AUDIO, adjusts AUDIO GAIN, and depresses TRACK switch

4.5.3 B-Scan Operator positions cursor on echo in range and bearing and observes correlation on B-Scan and PPI displays

4.5.4 A-Scan Operator may elect to depress B-Scan AUDIO switch and monitor B-Scan audio channel

4.5.5 Tracking Console Operator depresses B-Scan switch and SSI switch to connect and control Omni Channel

4.5.6 Tracking Console Operator observes echo on GI display and manipulates hand wheel to obtain doppler indication

4.5.7 B-Scan Operator and Supervisor observe 3-ping history on B-Scan

4.5.8 Change settings of RANGE SCALE - KILOYARDS, XMTR POWER LEVEL - DB, PULSE LENGTH, PPI SUM/PPI DIFF, NOTCH IN/NOTCH OUT as necessary to intensify the echo and obtain good detection

4.5.9 Repeat 4.5.3 to 4.5.8 as necessary for step 4.5.11

4.5.10 B-Scan and Tracking Console Operator communicate opinions regarding contact to Supervisor

4.5.11 Supervisor makes initial classification as NON-SUBMARINE or POSSIBLE SUBMARINE. If NON-SUBMARINE, resume search. If POSSIBLE SUBMARINE, Supervisor orders B-Scan Operator to depress ON TARGET switch

4.6 Investigate noise indication on passive recorder

4.6.0 Supervisor has observed noise indication on passive recorder trace

4.6.1 Plug in ear-phone and adjust AUDIO GAIN as necessary

4.6.2 Rotate SIGNAL BEARING dial to bearing of audio and visual trace

4.6.3 Make decision on basis of audio and recorder trace of possible source of noise

4.6.4 If noise warrants, alert both A-Scan and B-Scan Operators to investigate bearing, and notify bridge and CIC of bearing

4.6.5 If echo is detected on either console, proceed as in 4.1, 4.2, 4.4, 4.5 as appropriate. If not detected, continue observations

Block 5. Track Target

5.1 Track POSSIBLE SUBMARINE target in CZ mode

5.1A If over 50,000 yards range

5.1A.0 A-Scan Operator has depressed ON TARGET switch

5.1A.1 Tracking Console Operator depresses SSI AIDED TRACK switch to regain control of cursor

5.1A.2 On each successive echo, Tracking Console Operator depresses PRESS TO TRAIN switch and positions

cursor on target echo on SSI and manipulates hand wheel to determine range rate on GI indicator

5.1A.3 Tracking Console Operator verbally announces SOUND RANGE in KILOYARDS, BEARING and RANGE RATE in KNOTS as ordered

NOTE: Transmitted to CIC for plotting may be accomplished by SONAR TALKER position or by direct phone lines by Tracking Console Operator.

5.1A.4 A-Scan Operator continues to monitor A-Scan display for other echoes and B-Scan Operator continues to monitor B-Scan or PPI for echoes

5.1A.5 Continue above until target is lost or change of mode is received or ordered by Supervisor

5.1B If under 50,000 yards range

5.1B.0 A-Scan Operator has depressed ON TARGET switch

5.1B.1 Tracking Console Operator depresses SSI AIDED TRACK switch to regain control of the cursor

5.1B.2 On each successive echo, Tracking Console Operator depresses PRESS TO TRAIN switch, positions cursor on target echo on SSI and manipulates hand wheel to determine range rate on GI

5.1B.3 Mk 53 Operator positions switch in switchboard to route range and bearing data to NC-2 Plotter in CIC

5.1B.4 CIC Plotter plots target on NC-2 Plotter

5.1B.5 A-Scan Operator continues to monitor A-Scan for other echoes and B-Scan Operator continues to monitor B-Scan and PPI for other echoes

5.1B.6 Continue until target is lost or a change of mode is ordered by Supervisor

5.2 Track possible submarine in BB mode

5.2.0 A-Scan Operator has depressed ON TARGET switch

5.2.1 Tracking Console Operator depresses SSI switch to regain control of cursor

5.2.2 On each successive return, Tracking Console Operator notes echo on SSI, positions cursor on the echo and depresses PUSH TO TRAIN switch to transmit NDT to FCS

NOTE: Mk 53 Console range is limited to 40,000 yards. If target is beyond this range, proceed as in 5.1A or 5.1B to track target in CIC.

5.2.3 A-Scan Operator continues to monitor A-Scan display for other echoes

5.2.4 When the Mk 53 Operator has a solution, he depresses the DIRECTOR CONTROL button which causes the AIDED TRACK AVAIL lamp to flash on the A-Scan and Tracking Consoles

5.2.5 Supervisor observes consistency of echoes and apparent tracking smoothness on A-Scan and SSI Consoles, makes decision to accept or not accept Aided Tracking, and orders A-Scan Operator accordingly

NOTE: If aided tracking is not acceptable, continue with 5.2.2. If acceptable, proceed with 5.2.6

5.2.6 A-Scan Operator depresses AIDED TRACK switch which causes AIDED TRACK lamps on A-Scan and Tracking consoles to illuminate

5.2.7 On successive returns, Track Console Operator notes position of echo relative to SSI center. If centered, PUSH TO TRAIN switch is depressed without moving cursor; if not centered, PUSH TO TRAIN switch is depressed and cursor is centered on echo to transmit correction to FCS

5.2.8 On successive returns, continue above until target is lost or until Supervisor orders a change of mode

5.3 Track Possible Submarine in BBT mode (not used)

5.4 Track targets in ODT mode

5.4.1 Supervisor orders B-Scan Operator to depress ON TARGET switch

5.4.2 B-Scan Operator begins verbal announcement of range and bearing

5.4.3 On successive returns, B-Scan Operator positions cursor on echo with joystick until Tracking Operator assumes control

5.4.4 Tracking Console Operator notes echo on SSI and depresses SSI switch to ON. (Tracking Console Operator now has control)

5.4.5 On successive returns, Tracking Console Operator notes echo on SSI and if not in the center, then positions cursor on echo and generates NDT by depressing PUSH TO TRAIN switch

5.4.6 Tracking Console Operator observes GI display and rotates hand wheel to determine range rate

5.4.7 B-Scan Operator continues to monitor B-Scan display and PPI for other echoes

5.4.8 Mk 53 Operator manipulates cursor and speed shadow upon receipt of successive NDT signals from Sonar, obtains a TARGET COURSE and SPEED SOLUTION, and depresses DIRECTOR CONTROL button

5.4.9 AIDED TRACK AVAIL lamps flash on B-Scan and Tracking Consoles which notify Sonar that Mk 53 has solution

5.4.10 Supervisor notes AIDED TRACK AVAIL lamp flashes, notes smooth tracking on B-Scan and SSI displays, decides to accept AIDED TRACK and so orders B-Scan Operator

NOTE: If Supervisor decides that tracking or solution is not acceptable, continue with 5.4.5.

5.4.11 B-Scan Operator depresses AIDED TRACK button and continues to monitor B-Scan and PPI for other echoes

5.4.12 Tracking Console Operator monitors successive returns on SSI and if echo appears at center, depresses PRESS TO TRAIN switch without moving joystick. If echo does not appear at center, Operator depresses PRESS TO TRAIN switch, positions cursor on echo and releases PRESS TO TRAIN switch to transmit correction to Mk 53 Computer

5.4.13 Continue 5.4.12 until attack is made or Supervisor orders a change of mode

5.5 Track targets in RDT mode

5.5.1 Supervisor orders B-Scan Operator to depress ON TARGET switch

5.5.2 On successive returns, B-Scan Operator positions cursor on echo with joystick until Tracking Console Operator assumes control

5.5.3 Tracking Console Operator detects echo on SSI and depresses SSI switch to ON

5.5.4 Tracking Console Operator begins verbal announcement of range and bearing of contact

5.5.5 On successive returns, Tracking Console Operator notes echo on SSI and if not centered, positions cursor on echo and depresses PUSH TO TRAIN switch to generate NDT

5.5.6 Tracking Console Operator observes GI display and rotates hand wheel to determine range rate

5.5.7 B-Scan Operator continues to monitor B-Scan display and PPI for other echoes

5.5.8 Mk 53 Operator manipulates cursor and speed shadow after each NDT from Sonar, obtains a target course and speed solution and depresses DIRECTOR CONTROL button

5.5.9 AIDED TRACK AVAIL lamps flash on B-Scan and Tracking Consoles to notify Sonar that Mk 53 has solution

5.5.10 Supervisor notes AIDED TRACK AVAIL lamp flashes, notes smooth and consistent tracking on SSI and B-Scan displays and makes decision to accept AIDED TRACK. If decision is to not accept, continue 5.5.4 through 5.5.9

5.5.11 B-Scan Operator depresses AIDED TRACK switch

5.5.12 Tracking Console Operator continues to monitor successive returns on SSI and if centered, depresses NDT without moving joystick. If not centered,

Operator positions cursor and depresses NDT button to transmit correction to Mk 53

5.5.13 Continue 5.5.12 until attack is made or Supervisor orders a change of mode

Block 6. Attack Phase with Sonar Data

6.1 Attack with CZ sonar data

NOTE: An attack cannot be made with CZ data directly because horizontal range is erroneous. Also, CZ range is beyond the limits of the FCS and CIC plotters. Targets in the convergence zone are also beyond the range of presently available own ship weapons. Sonar will maintain contact as in 5.1 until support units can be vectored to attack by CIC.

6.2 Attack with BB sonar data

NOTE: An attack with own ship weapons cannot be made successfully with BB sonar data because the range data obtained by the BB mode is inaccurate. Own ship will maintain contact plot, determine a course and speed on target, even though in error, and will vector a support unit to the datum point or will close with target to reduce range and detect target in surface duct mode. When target is detected in ODT portion of BB/ODT, system should switch to ODT or RDT

6.3 Attack phase in BBT mode (not used)

6.4 Attack phase with ODT mode sonar data

6.4.0 Sonar has accepted AIDED TRACK from FCS

6.4.1 On each sonar return, Tracking Console Operator notes position of echo on SSI and if centered, presses NDT. If not centered, positions cursor on echo, and then presses NDT to transmit correction to FCS

6.4.2 During preparation to attack, B-Scan and A-Scan Operators observe displays for other echoes

6.4.3 When order to fire is given, B-Scan Operator rotates RANGE SCALE switch to LISTEN

NOTE: If sub is not alerted, 6.4.3 to 6.4.12 may be omitted and active ranging continued, as in Block 5.

6.4.4 B-Scan Operator listens for torpedo on audio and watches for torpedo noise spoke on PPI display

6.4.5 B-Scan Operator calls out torpedo information on intercom and reports explosion if it occurs

6.4.6 If explosion occurs, Operator listens for, and reports on sound effects of submarine destruction

6.4.7 If explosion does not occur within two minutes after torpedo begins run, Operator reports no explosion

6.4.8 B-Scan Operator switches to appropriate range scale, SEARCH, and POSITION KEEP to match cursor with Mk 53 data

6.4.9 When target is detected, Operator switches to TRACK, aligns cursor, depresses ON TARGET

6.4.10 Tracking Console Operator depresses SSI, positions cursor ON TARGET

6.4.11 Mk 53 Operator obtains solution and depresses DIRECTOR CONTROL button

6.4.12 B-Scan Operator depresses AIDED TRACK button

6.4.13 Continue attack as in 6.4.1

6.4.14 If other echoes are observed during attack phase, A-Scan Operator, B-Scan Operator or Supervisor, calls out range and bearing of new contact on intercom system

6.4.15 Bridge or CIC makes decision on which target to track on Mk 53 and attack first

6.4.16 Continue attack on primary target as above and call out range and bearing of secondary target on intercom

6.4.17 Continue until all targets are destroyed, target is lost, or order to resume search is given

6.5 Attack with RDT mode sonar data
Same procedure as with ODT data (See 6.4.0 to 6.4.17)

Block 7. Lost Contact Procedure

7.1 Conduct lost target search in CZ mode

7.1.0 Echo has failed to appear on a number of successive pings after contact phase was in progress

7.1.1 Sonar Supervisor reports NO ECHOES to Bridge and CIC and orders LOST TARGET SEARCH doctrine

7.1.2 A-Scan Operator positions cursor to ping in 10° steps both to left and right of last known position, observes A-Scan display, and listens for echo

7.1.3 Tracking Console Operator observes SSI and listens for echo on individual channels

7.1.4 If contact is found, Supervisor reports REGAIN CONTACT to Bridge and CIC. Block 4 (Contact phase) is continued

7.1.5 If contact is not found on doctrine search, Supervisor reports LOST CONTACT to Bridge and CIC

7.1.6 CIC recommends sector range and bearing to search

7.1.7 If contact is found, Supervisor reports sonar contact and proceeds as in Block 4

7.1.8 If contact is not found, Supervisor repeats 7.1.6 or resumes search as in Block 3

7.2 Conduct lost target search in BB mode. Use identical procedure to 7.1

7.3 Lost target procedure in BBT mode (Not used)

7.4 Conduct lost target search in ODT mode

- 7.4.0 Echo has failed to appear on repeated returns after contact phase was in progress
- 7.4.1 Sonar Supervisor reports NO ECHOES to Bridge and CIC and orders LOST TARGET SEARCH doctrine
- 7.4.2 B-Scan Operator positions cursor in 10° increments to left and right of last contact bearing and listens for echo on single beam audio
- 7.4.3 Tracking Console Operator observes SSI and listens for echo on audio
- 7.4.4 If contact is found, Supervisor reports REGAIN CONTACT to Bridge and CIC. Block 4 (Contact phase) is continued
- 7.4.5 Changes in equipment settings are made to enhance reception as necessary
- 7.4.6 If contact is not found during doctrine search, Supervisor reports LOST CONTACT to Bridge and CIC
- 7.4.7 CIC recommends sector range and bearing to search
- 7.4.8 If contact is found, report SONAR CONTACT and proceed as in Block 4
- 7.4.9 If contact is not found, repeat 7.4.6 or resume normal search as in Block 3

7.5 Conduct lost target search in RDT mode (Same as 7.4 procedure)

APPENDIX C

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

FINE DETAIL TASK LIST

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APPENDIX C

FINE DETAIL TASK LIST

Block 3. Conduct Search and Surveillance
- 3.1 Conduct search in CZ mode.
  - 3.1.0 Check that CZ lamp, XMTR ON lamp and SEARCH lamp are lighted (For ODT search, See 3.4)
  - 3.1.1 Make specific equipment settings (for CZ mode)
    - 3.1.1.1 Set ZONE WIDTH switch to 20 KILO-YDS
    - 3.1.1.2 Set MANUAL RANGE knob to minimum range desired as determined on checklist (Block 1)
    - 3.1.1.3 Set TILT ANGLE knob to optimum as determined on checklist (Block 1)
    - 3.1.1.4 Set FM/PRN switch to FM
    - 3.1.1.5 Adjust AUDIO GAIN to desired level
  - 3.1.2 Select desired bearing
    - 3.1.2.1 Depress PRESS TO TRAIN (New Data Time) switch
    - 3.1.2.2 Move cursor control laterally and observe desired bearing readout
    - 3.1.2.3 Depress SECTOR TRAIN switch
    - 3.1.2.4 Wait for flyback interval
    - 3.1.2.5 Observe that BEARING readout and BB/CZ SECTOR CENTER readout coincide
    - 3.1.2.6 Observe that SECTOR FREEZE lamp is lighted
    - 3.1.2.7 Depress RECYCLE switch (if desired)
  - 3.1.3 Operator monitors A-Scan display and audio channel for echoes

    NOTE: System will continuously recycle approximately every 75 seconds with 3 returns per cycle. Operator cannot tell which part of cycle is displayed.

    Operator monitors returns and may change selected settings as in 3.1.1 and may change desired bearing as in 3.1.2 at various times during a search period.
  - 3.1.4 Operator detects echo on A-Scan display.
- 3.2 Conduct search in BB/ODT mode. (For ODT search, see 3.4 below)
  - 3.2.0 Check that BB/ODT lamp, XMTR ON lamp and SEARCH lamp are lighted
  - 3.2.1 Make specific equipment settings for BB/ODT
    - 3.2.1.1 Set ZONE RANGE switch for MANUAL operation
    - 3.2.1.2 Set ZONE WIDTH switch for either 10,000 yds or 20,000 yds

3.2.1.3 Set MANUAL RANGE knob to minimum range desired
3.2.1.4 Set TILT ANGLE knob to desired depression angle
3.2.1.5 Set FM/PRN switch to FM
3.2.1.6 Set FREQUENCY CHANNEL knob to desired sound frequency
3.2.1.7 Adjust audio gain to desired level

3.2.2 Select desired bearing
3.2.2.1 Depress PRESS TO TRAIN button
3.2.2.2 Move cursor control laterally and observe BEARING read out
3.2.2.3 Depress SECTOR TRAIN switch
3.2.2.4 Wait for flyback interval
3.2.2.5 Observe that BEARING read out and BB/CZ SECTOR CENTER coincide
3.2.2.6 Observe that SECTOR FREEZE lamp is lighted
3.2.2.7 Depress RECYCLE switch (if desired)

3.2.3 Operator monitors A-Scan display and audio channel for echoes

NOTE: System will continuously recycle in selected mode per minimum range and zone width settings at a rate dependent on bottom depth (as an example, one return each 27 seconds for bottom depth of 2,000 fathoms at 20° tilt angle)

Operator monitors reach return, but may change selected control settings as in 3.2.1 and change desired bearing as in 3.2.2

3.2.4 Operator detects echo on A-Scan display

3.3 Conduct search in BBT mode
This mode can be used for search but is primarily for the tracking phase. If used for search, detail tasks are identical to BB portion of BB/ODT mode

3.4 Conduct search in ODT mode
(Includes ODT portion of BB/ODT and CZ except as noted)

3.4.0 Check that ODT (or BB/ODT or CZ) lamp, XMTR ON lamp, and SEARCH lamp are lighted

3.4.1 Make specific equipment settings
3.4.1.1 Observe that MULTI-AUDIO switch, PPI SUM switch and NOTCH OUT switch are illuminated
3.4.1.2 Set RANGE SCALE KILOYARDS knob to desired maximum sweep range
3.4.1.3 Set PULSE LENGTH-MS knob to desired position (In CZ and BB/ODT mode, setting of pulse length is automatic)

3.4.1.4 Set XMTR POWER LEVEL-DB knob to desired level (XMTR power level for all modes is controlled from the B-Scan Console)

3.4.1.5 Press RECYCLE button if desired (ODT only)

3.4.1.6 Adjust audio gain knob to desired level

3.4.2 Operator monitors B-Scan, PPI displays, and audio channel for echoes

NOTE: System will cycle continuously and at one of the following rates:

a. In CZ mode, 3 times for each CZ cycle
b. In BB mode, 1 time for each BB cycle
c. In ODT mode, dependent on setting of RANGE SCALE - KILOYARDS

Operator may elect to change settings in 3.4.1 at various times in the search period

3.4.3 Operator detects echo on B-Scan or PPI display

3.5 Conduct search in RDT mode

3.5.0 Check that RDT switch, XMTR ON switch and SEARCH switch are lighted

3.5.1 Make specific equipment settings

3.5.1.1 Check that MULTI-AUDIO switch, PPI SUM switch and NOTCH OUT switch are lighted

3.5.1.2 Set RANGE SCALE-KILOYARDS knob to desired sweep range

3.5.1.3 Set PULSE LENGTH-MS knob to desired position (1 of 4)

3.5.1.4 Set XMTR POWER LEVEL-DB to desired level (1 of 11)

3.5.1.5 Set RDT SECTOR WIDTH knob to desired width (1 of 9)

3.5.1.6 Adjust audio gain to desired level

3.5.2 Select desired Sector Center Bearing

3.5.2.1 Depress PRESS TO TRAIN switch

3.5.2.2 Move cursor control laterally and observe desired BEARING read out

3.5.2.3 Depress SECT TRAIN switch

3.5.2.4 Wait for flyback

3.5.2.5 Observe that BEARING read out and RDT SECTOR CENTER coincide

3.5.2.6 Observe that SECTOR FREEZE lamp is lighted

3.5.2.7 Depress RECYCLE switch if desired

3.5.3 Operator monitors B-Scan display, PPI and audio channel for echoes

NOTE: System will recycle continuously to ensonify the selected sector at a rate dependent on RANGE SCALE-KILOYARDS switch setting

Operator monitors each return and may elect to change settings as in 3.5.1 or to change SECTOR CENTER bearing as in 3.5.2, at various times during the watch period

3.5.4 Operator detects echo on B-Scan or PPI displays

3.6 Observe indication on passive recorder

3.6.0 Check that unit is energized by observing that illumination lamps are lighted and that RECORDER switch is ON

3.6.1 Periodically observe recorder display for echoes by noting a variation in pen traces

NOTE: Paper advances at a rate of one inch per minute. Since 7-1/2 inches of paper are visible, display should be observed at least once each 7-1/2 minutes or more often as necessary.

APPENDIX D

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

OPERATIONAL SEQUENCE DIAGRAMS

Prepared for:

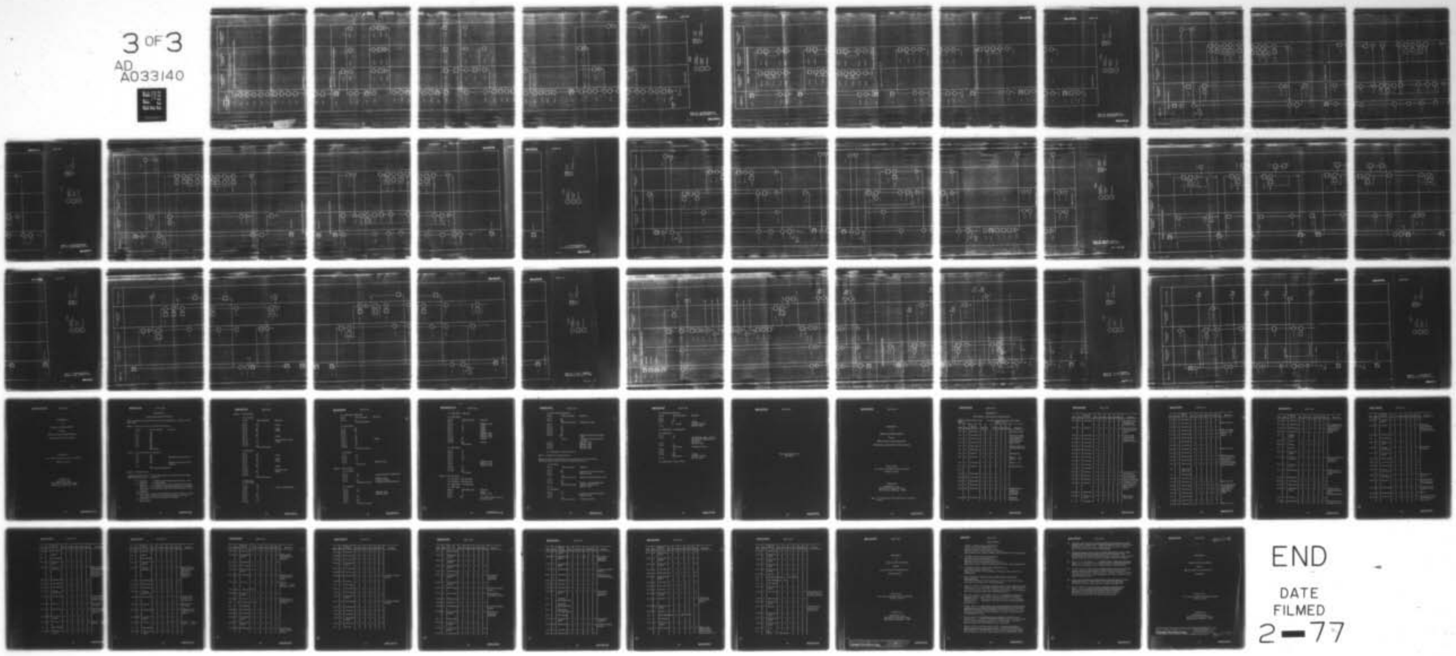
U. S. NAVAL TRAINING DEVICE CENTER
Orlando, Florida

Prepared by:

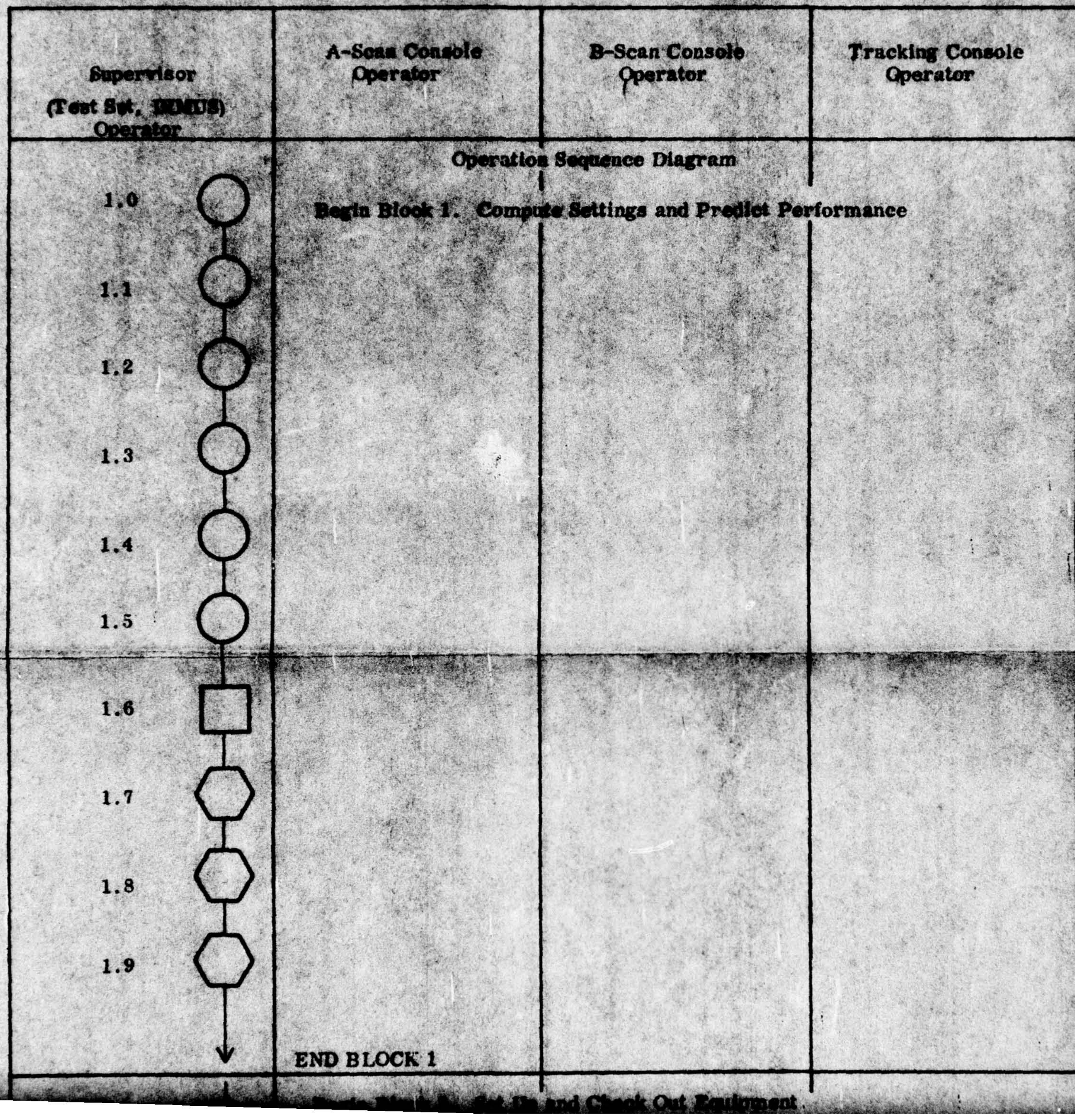
HONEYWELL INC.
1200 East San Bernardino Road
West Covina, California 91790

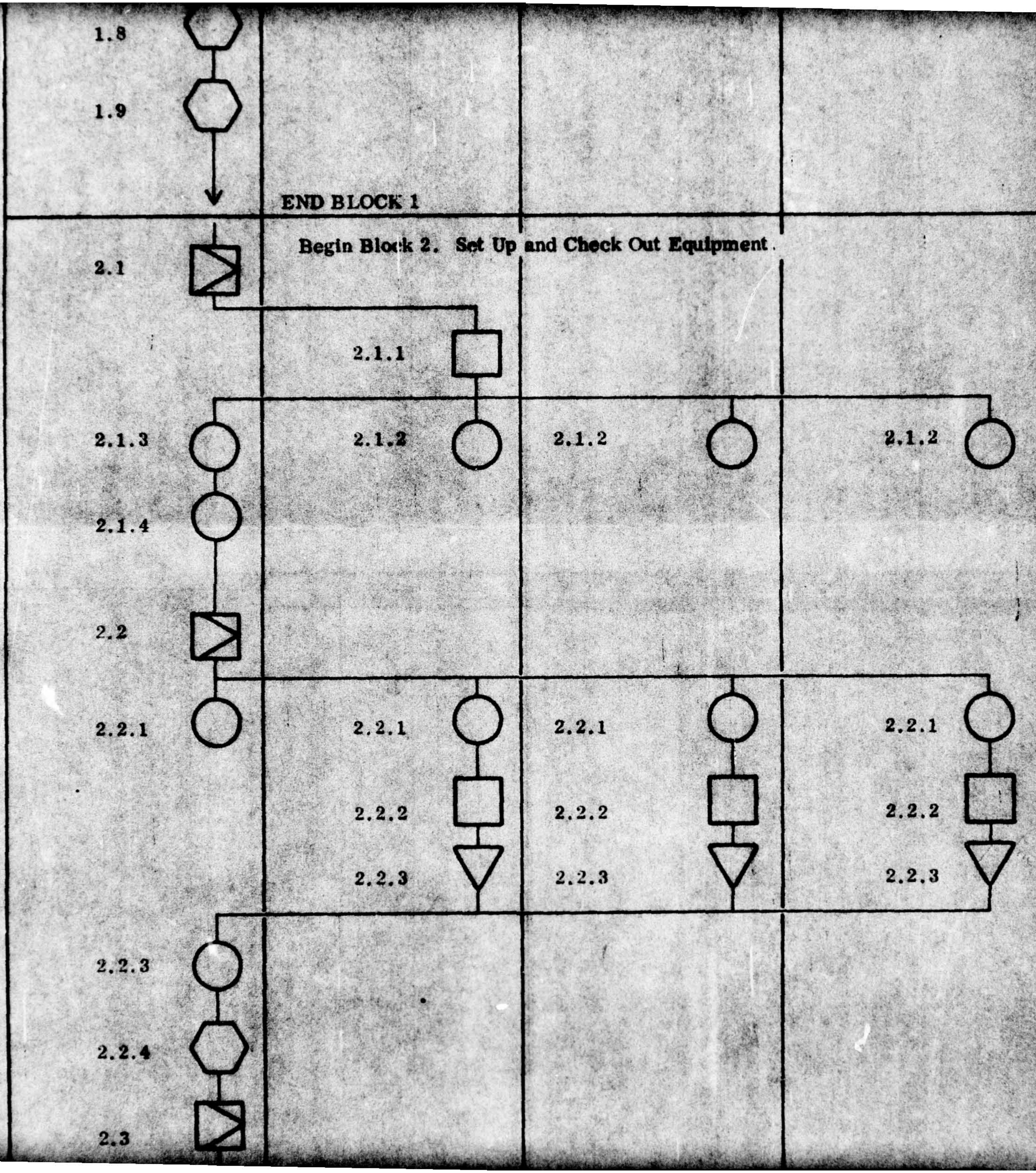
AD-A033 140 HONEYWELL INC WEST COVINA CALIF F/G 17/1
FINAL HUMAN FACTORS REPORT FOR THE SQS-26 SONAR SYNTHESIS STUDY--ETC(U)
OCT 67 B W YAEGER, L P SCHRENK N61339-67-C-0022
UNCLASSIFIED 422-67-WC NL

3 OF 3
AD
A033140



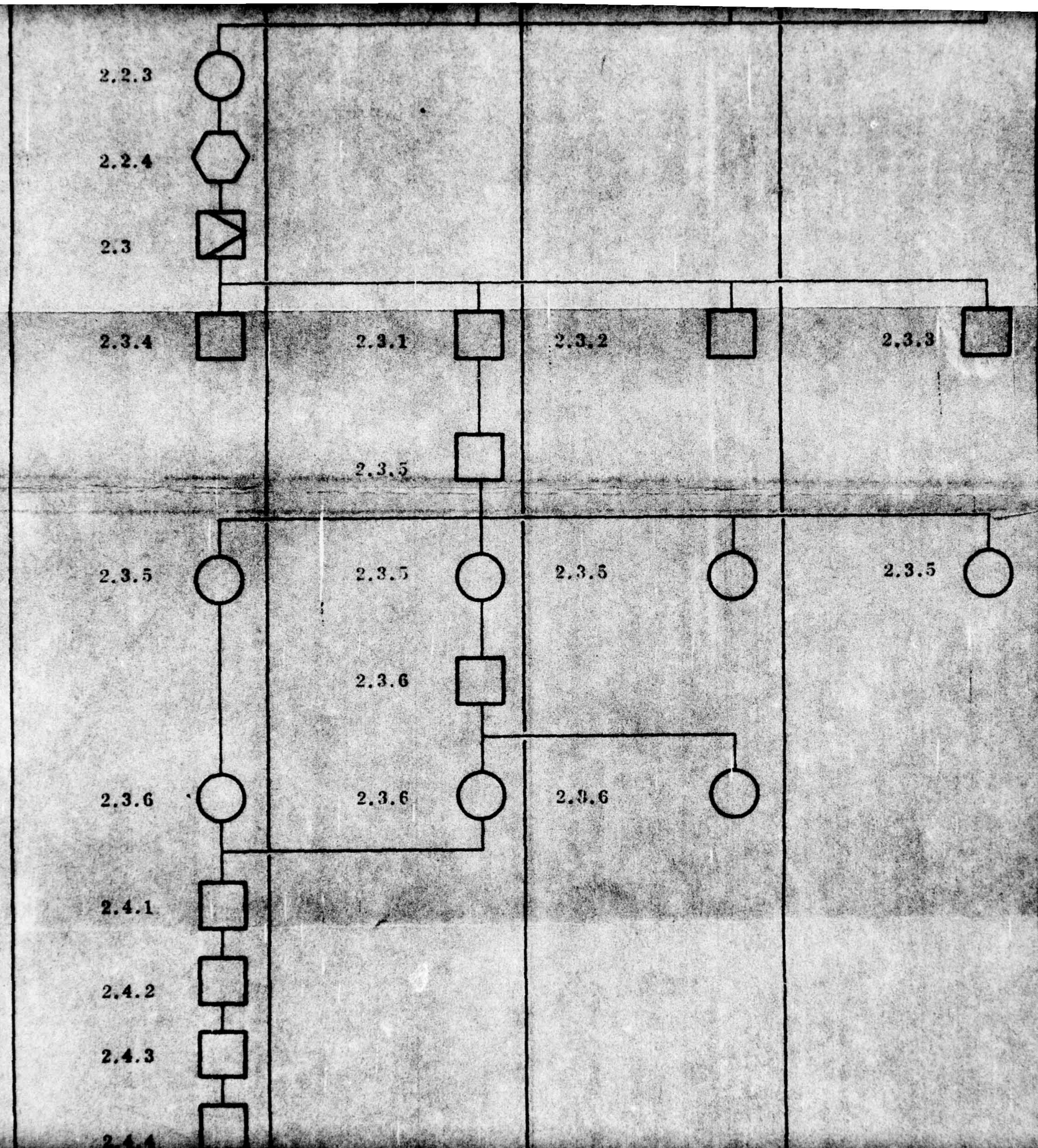
END
DATE
FILMED
2-77

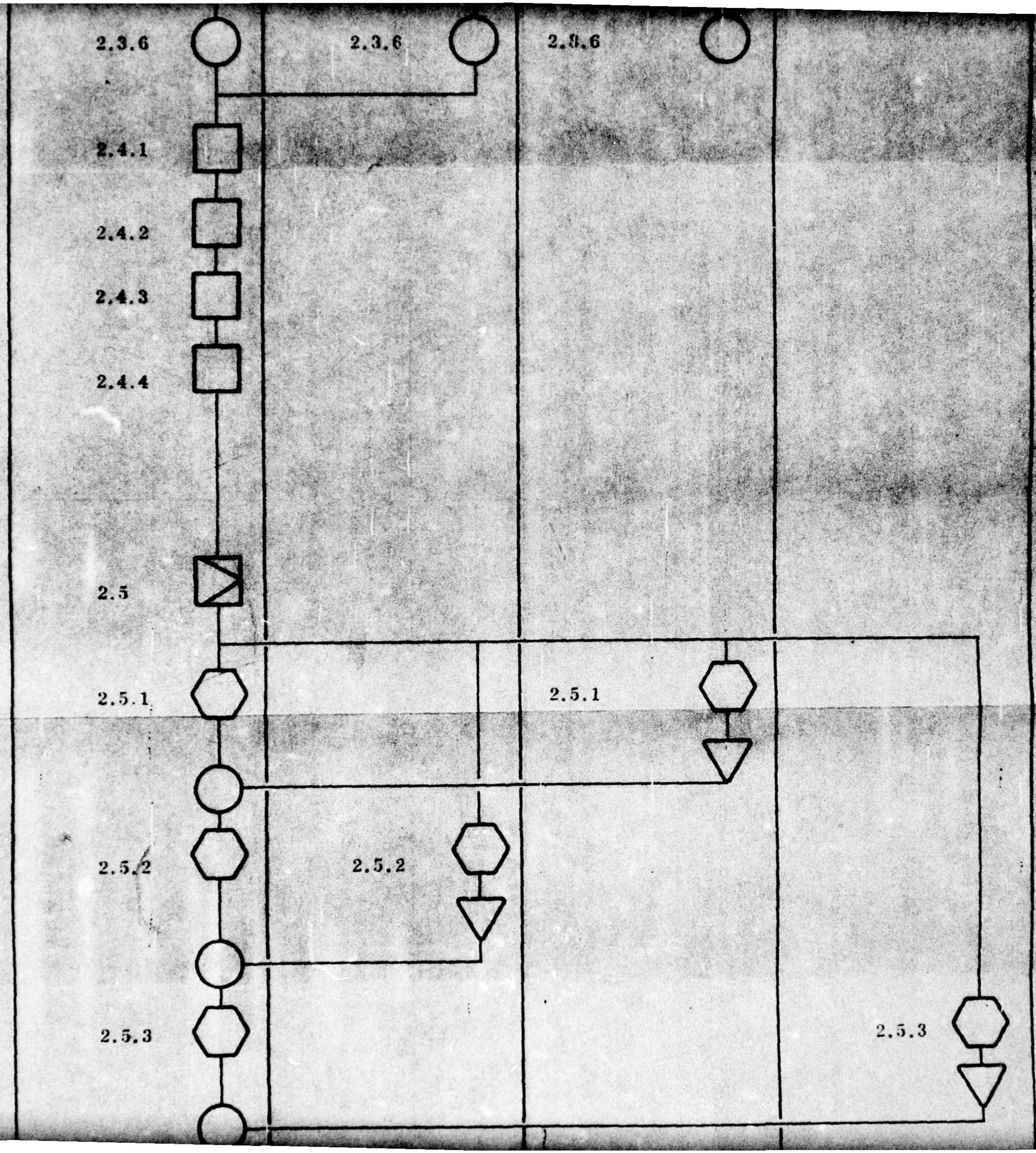

Supervisor
(Test Set, [redacted])
Operator
A-Scan Console
Operator
B-Scan Console
Operator
Tracking Console
Operator
Operation Sequence Diagram
Begin Block 1. Compute Settings and Predict Performance
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
END BLOCK 1



1.8
1.9
END BLOCK 1
Begin Block 2. Set Up and Check Out Equipment.
2.1
2.1.1
2.1.3
2.1.2
2.1.2
2.1.2
2.1.4
2.2
2.2.1
2.2.1
2.2.1
2.2.1
2.2.2
2.2.2
2.2.2
2.2.3
2.2.3
2.2.3
2.2.3
2.2.4
2.3

2


2.2.3
2.2.4
2.3
2.3.4
2.3.1
2.3.2
2.3.3
2.3.5
2.3.5
2.3.5
2.3.5
2.3.5
2.3.6
2.3.6
2.3.6
2.3.6
2.4.1
2.4.2
2.4.3
2.4.4



2.3.6
2.3.6
2.3.6
2.4.1
2.4.2
2.4.3
2.4.4
2.5
2.5.1
2.5.1
2.5.2
2.5.2
2.5.3
2.5.3

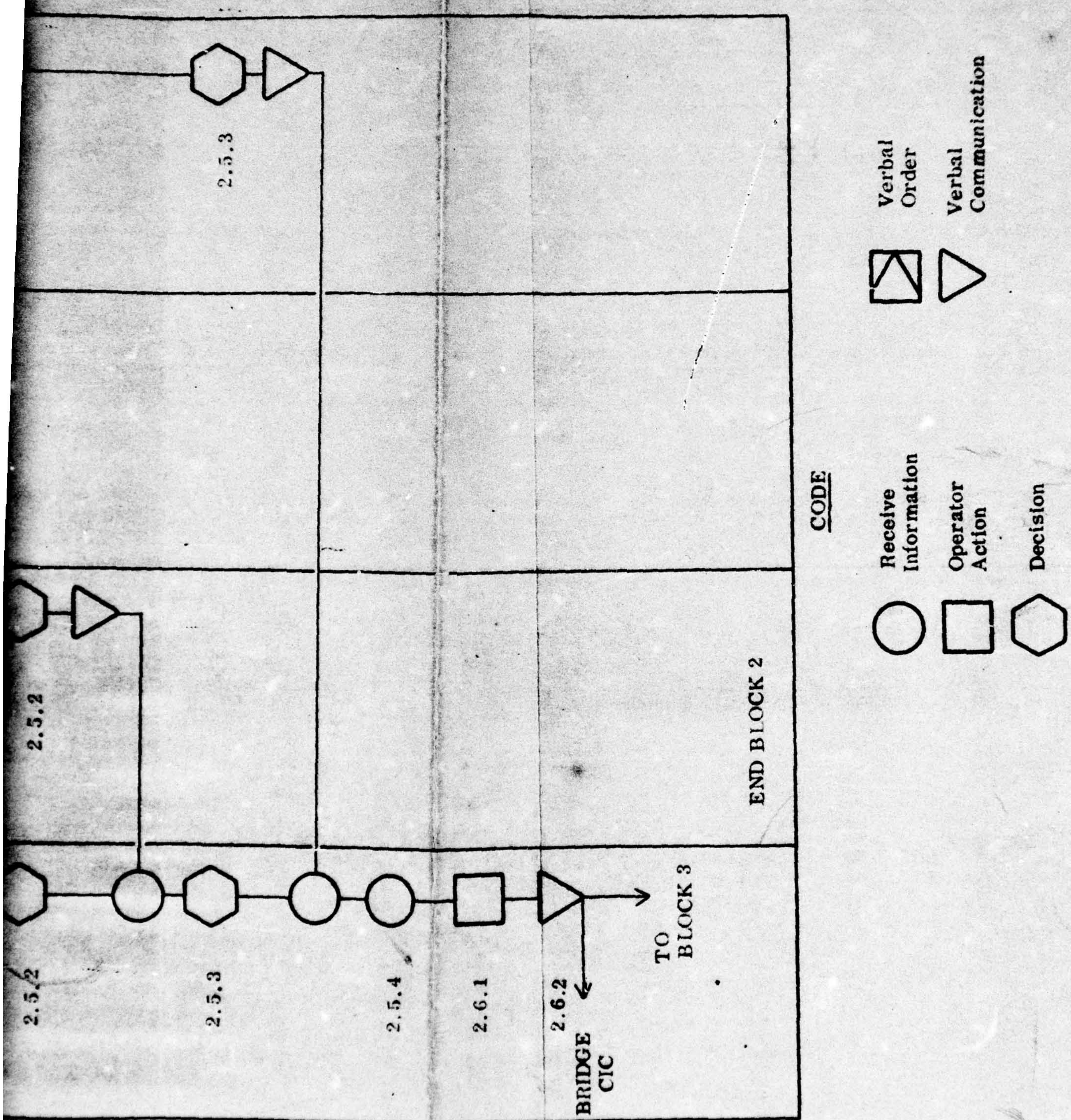
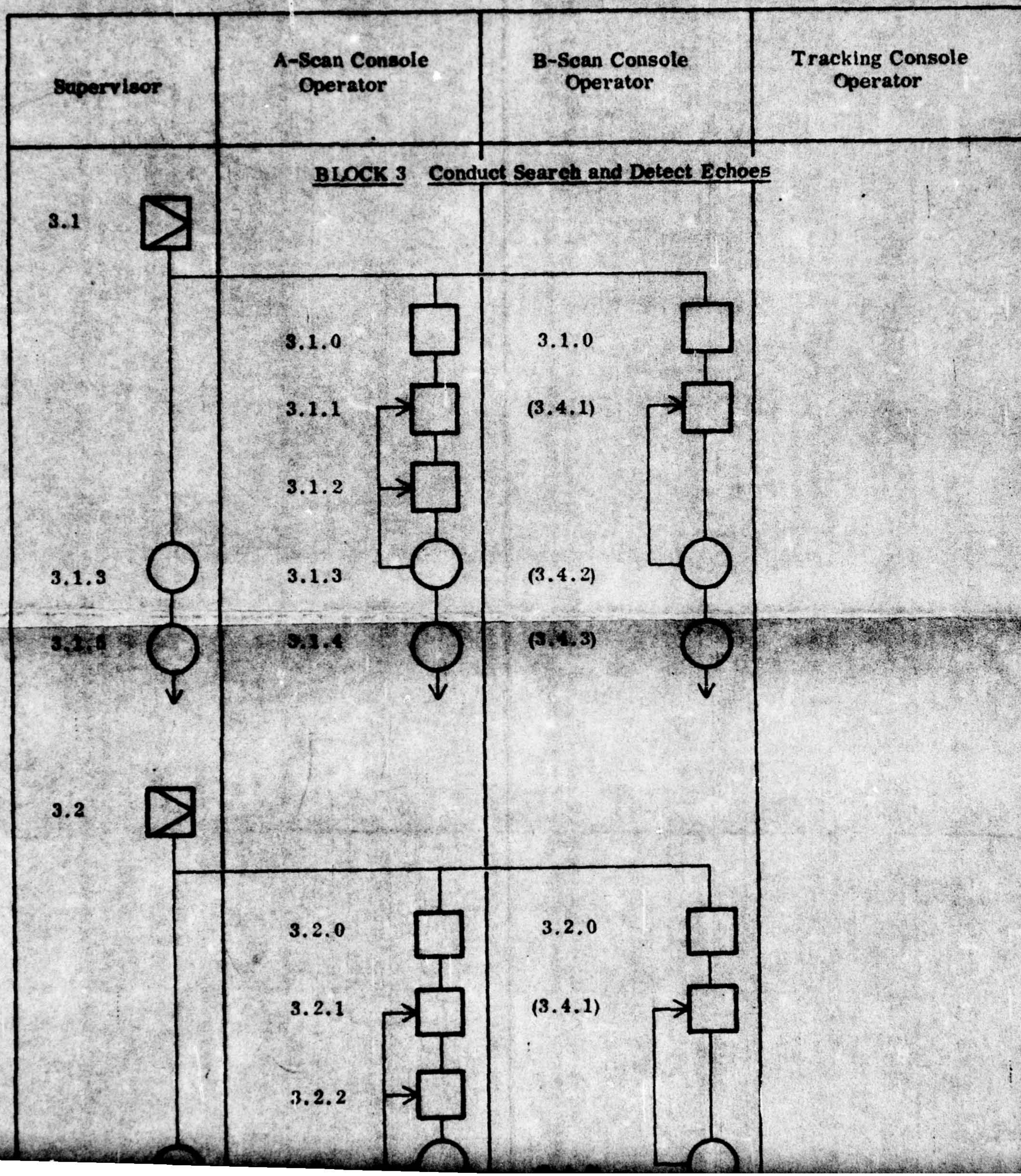
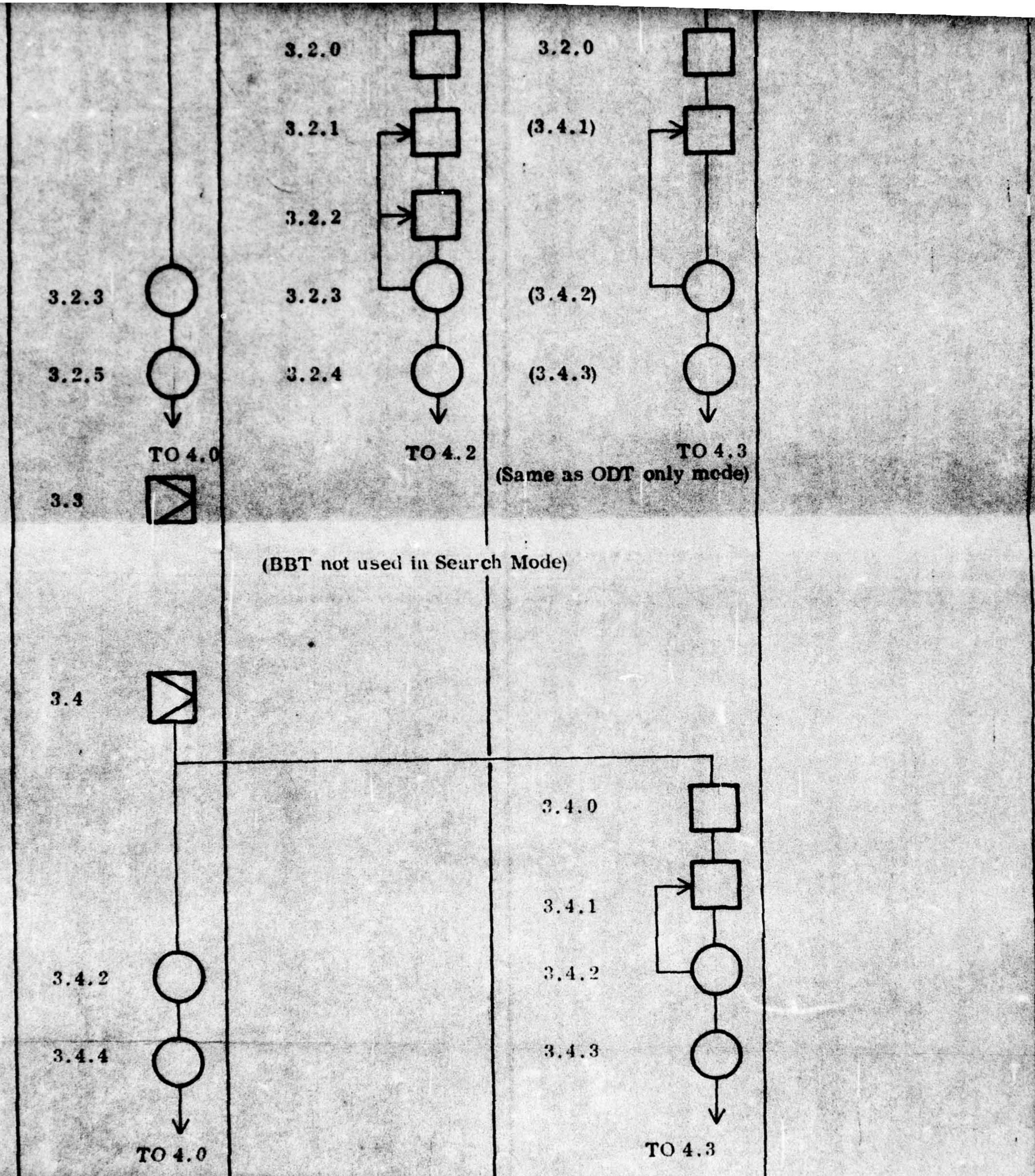


Figure 20. Operation Sequence Functional Diagram (Sheet 1 of 9)

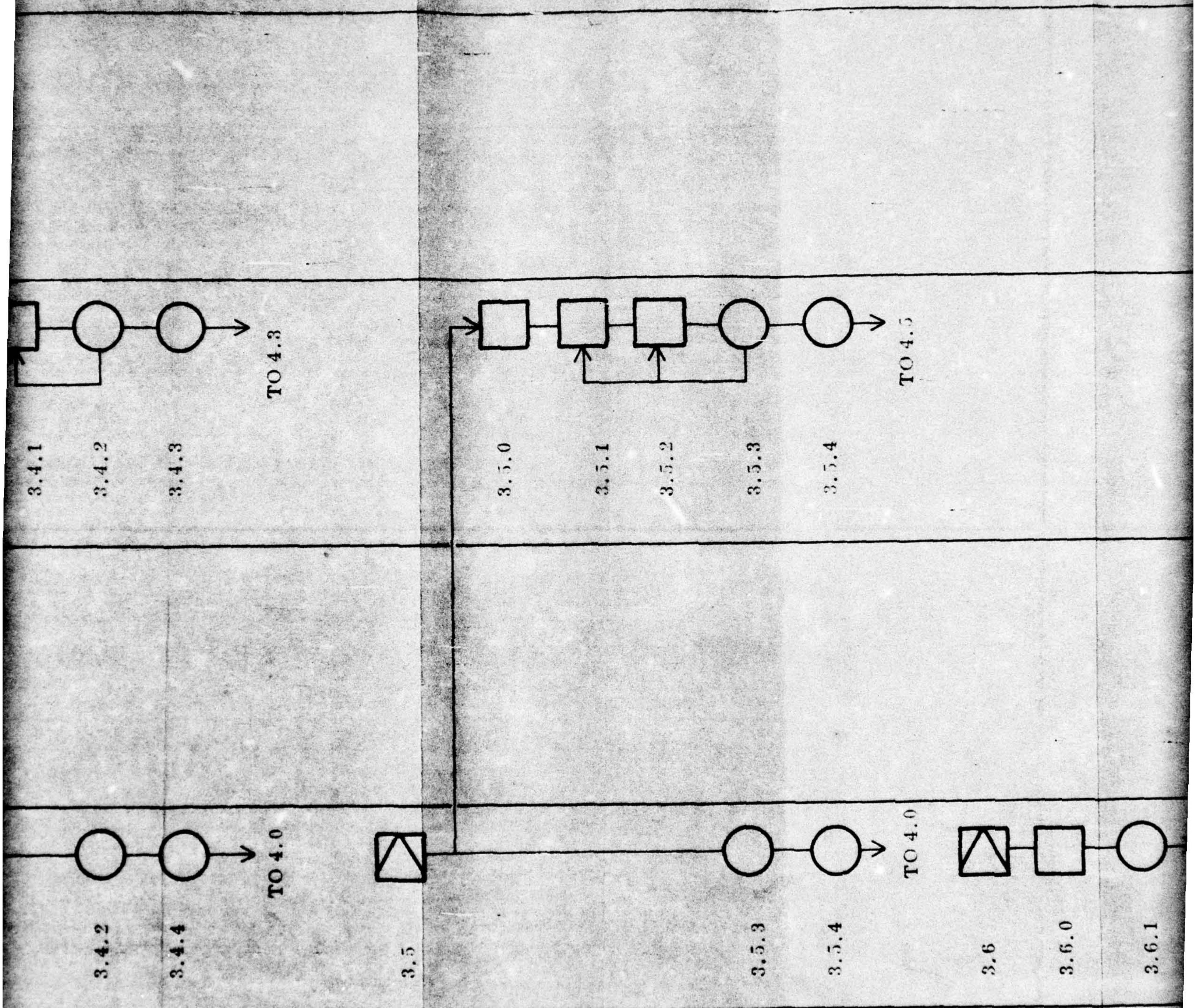


Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
BLOCK 3 Conduct Search and Detect Echoes
3.1
3.1.0
3.1.0
3.1.1
(3.4.1)
3.1.2
3.1.3
3.1.3
(3.4.2)
3.1.4
(3.4.3)
3.2
3.2.0
3.2.0
3.2.1
(3.4.1)
3.2.2



3.2.3
3.2.5
TO 4.0
3.3
3.2.0
3.2.1
3.2.2
3.2.3
3.2.4
TO 4.2
3.2.0
(3.4.1)
(3.4.2)
(3.4.3)
TO 4.3
(Same as ODT only mode)
(BBT not used in Search Mode)
3.4
3.4.2
3.4.4
TO 4.0
3.4.0
3.4.1
3.4.2
3.4.3
TO 4.3

UNCLASSIFIED



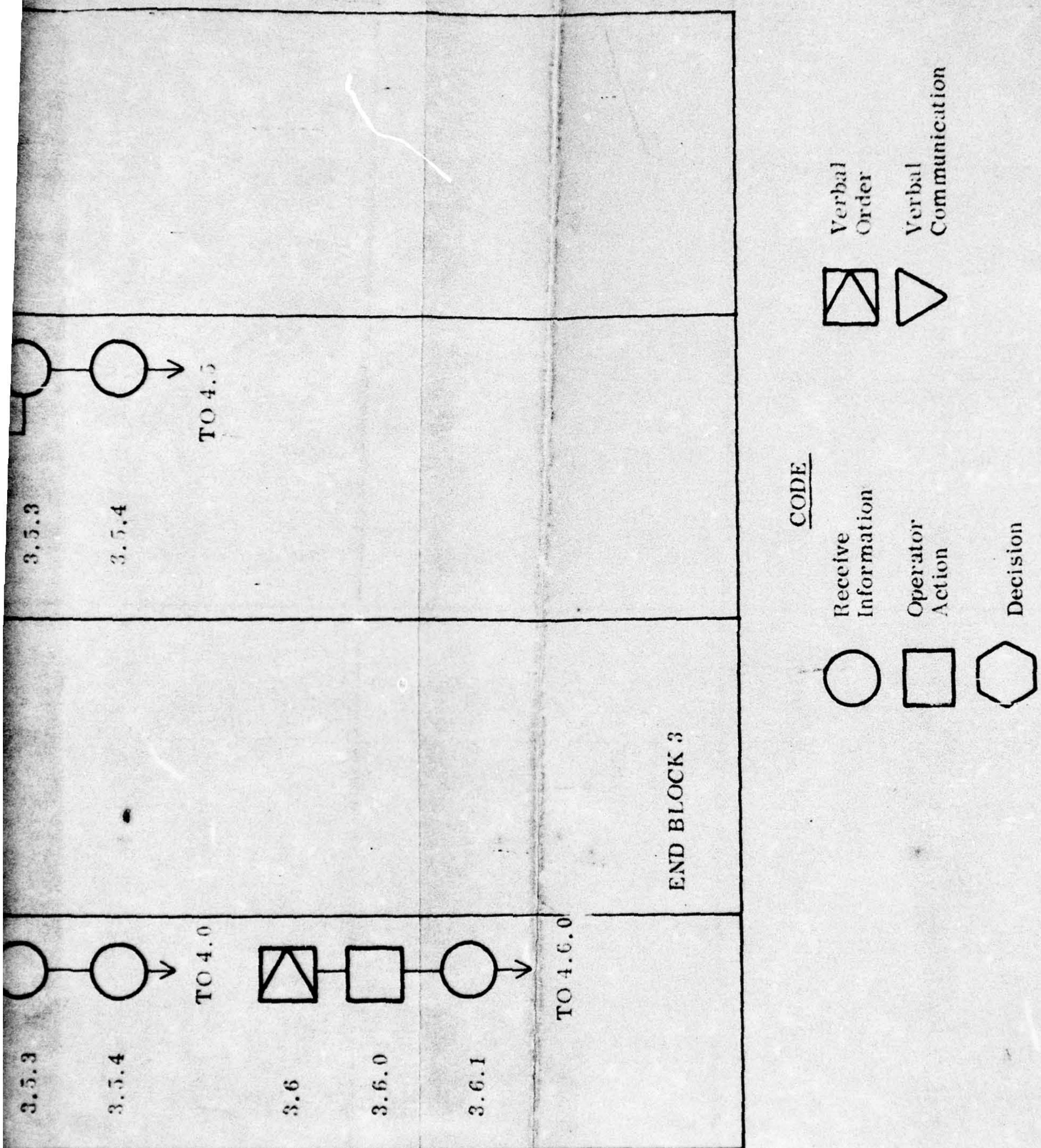
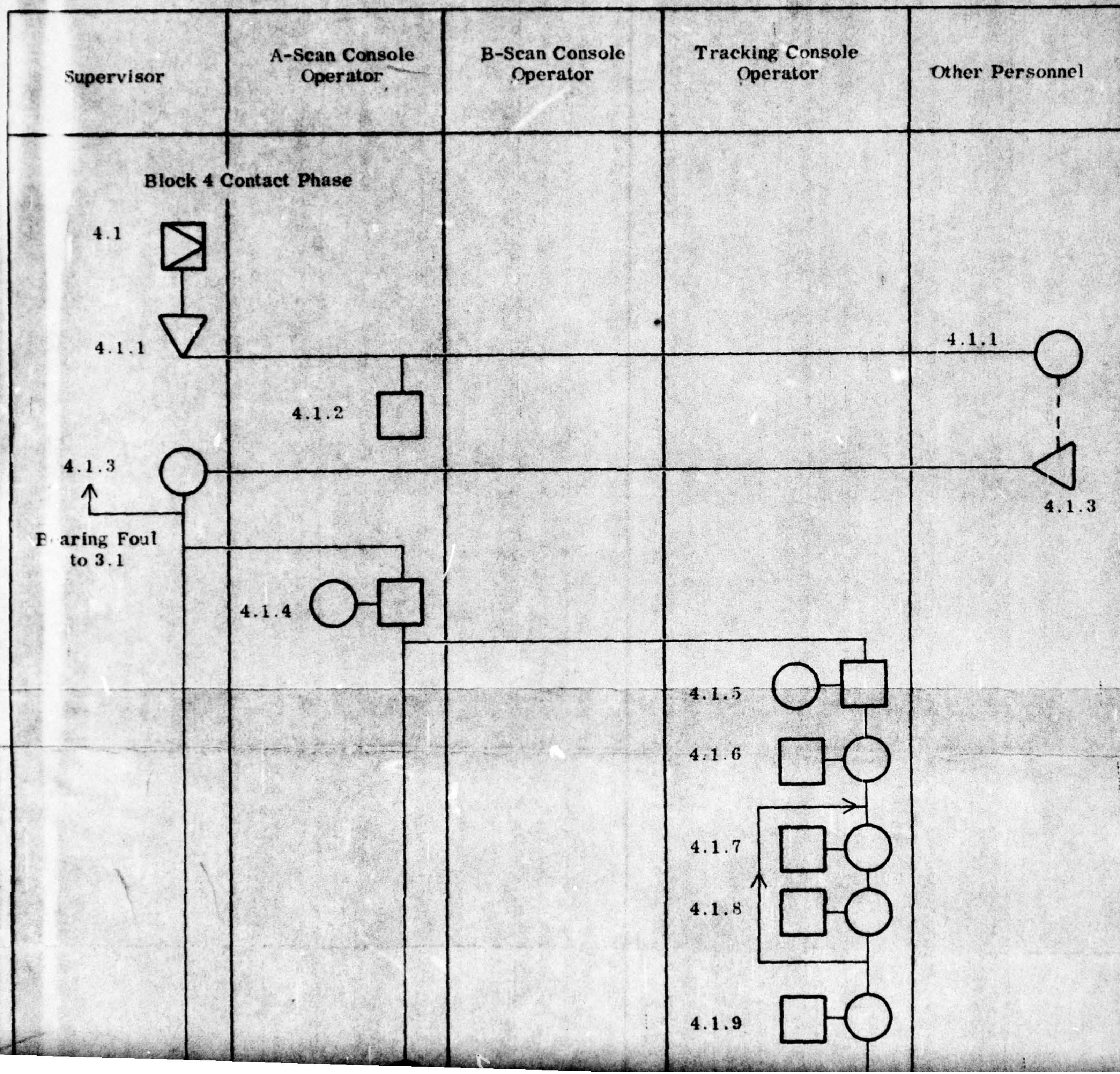
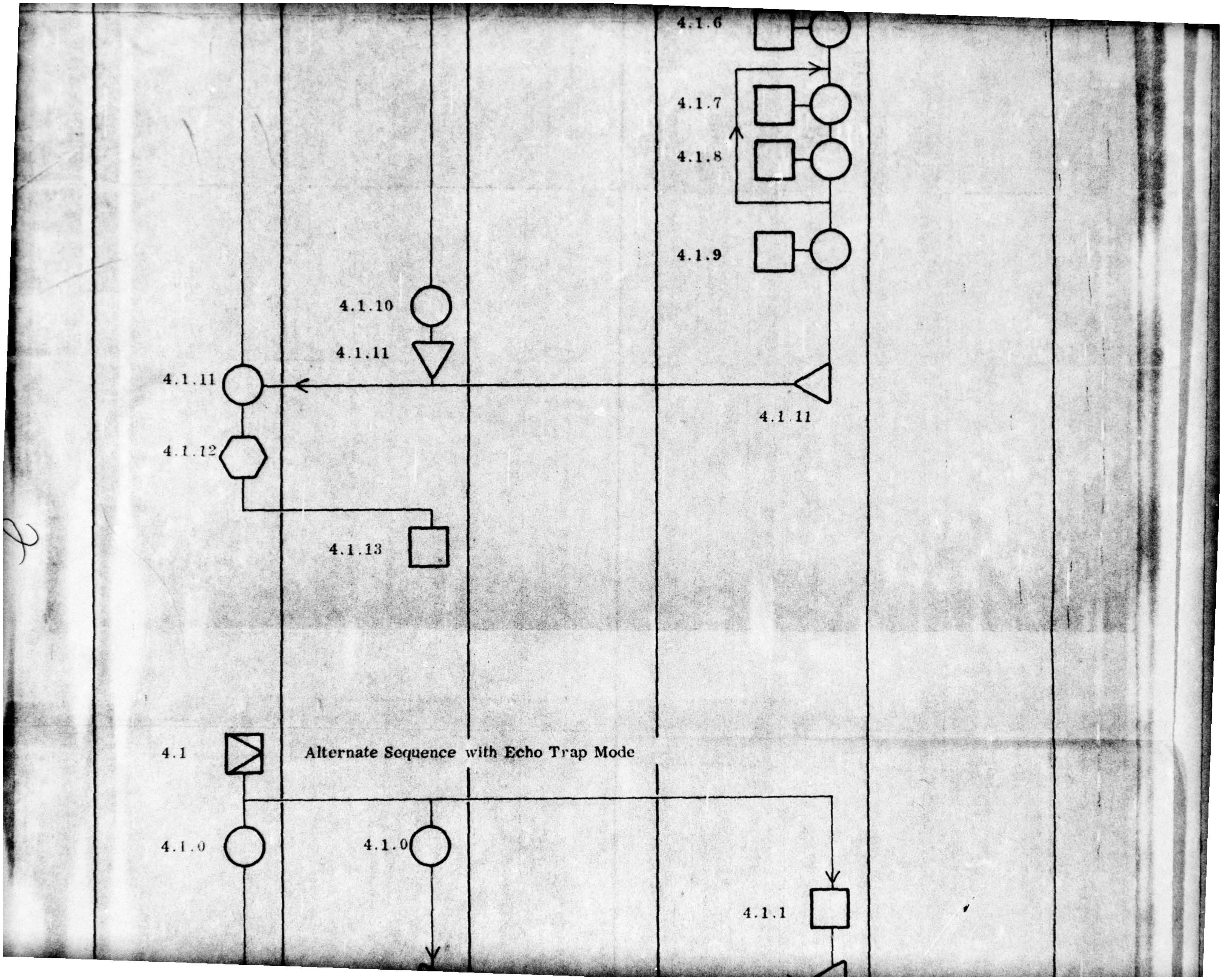


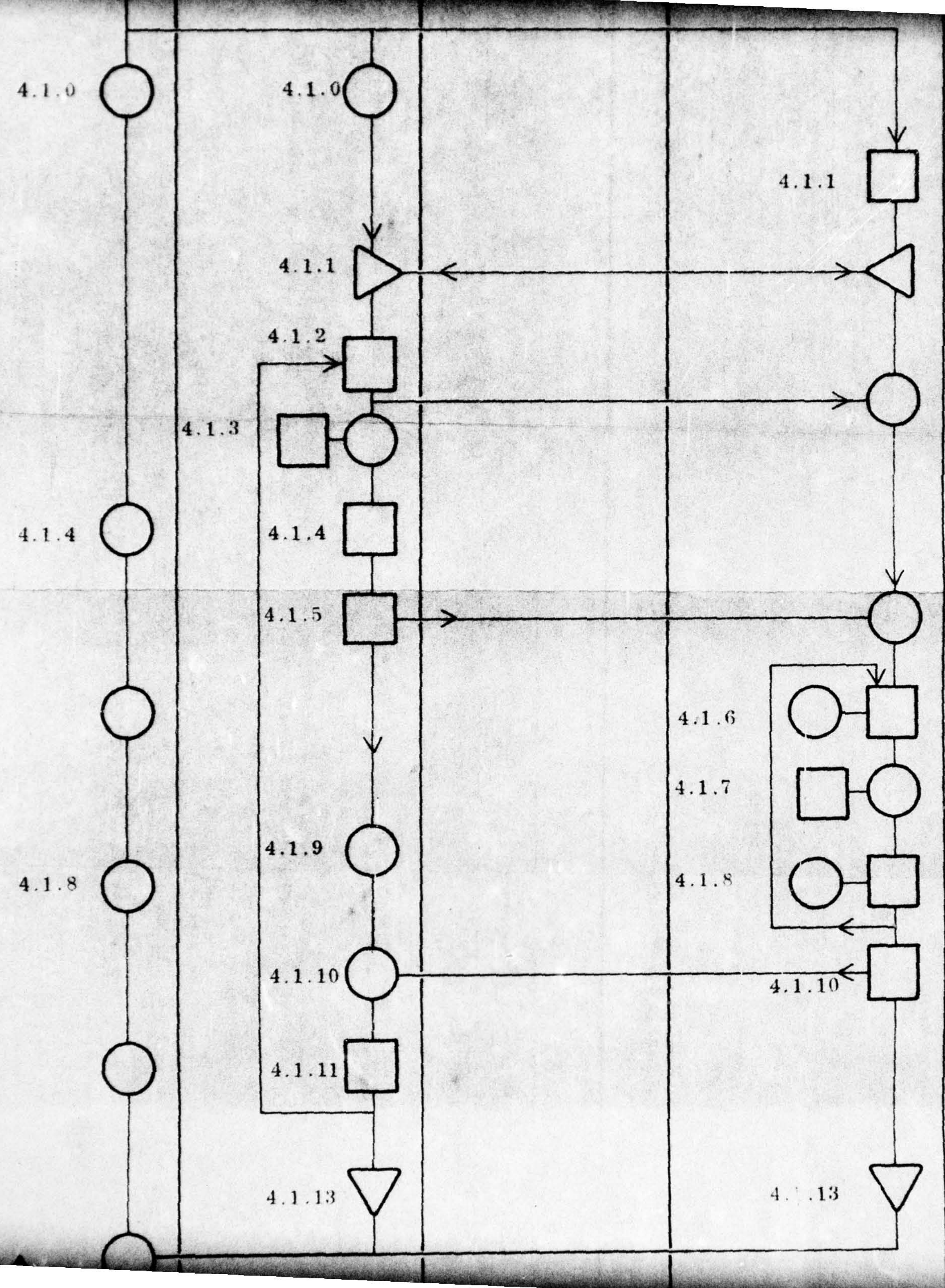
Figure 20. Operation Sequence Functional Diagram (Sheet 2 of 9)



Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
Block 4 Contact Phase
4.1
4.1.1
4.1.1
4.1.2
4.1.3
4.1.3
B aring Foul to 3.1
4.1.4
4.1.5
4.1.6
4.1.7
4.1.8
4.1.9



4.1.6
4.1.7
4.1.8
4.1.9
4.1.10
4.1.11
4.1.11
4.1.11
4.1.12
4.1.13
4.1
Alternate Sequence with Echo Trap Mode
4.1.0
4.1.0
4.1.1


4.1.0
4.1.0
4.1.1
4.1.1
4.1.2
4.1.3
4.1.4
4.1.4
4.1.5
4.1.6
4.1.7
4.1.8
4.1.9
4.1.8
4.1.10
4.1.10
4.1.11
4.1.13
3

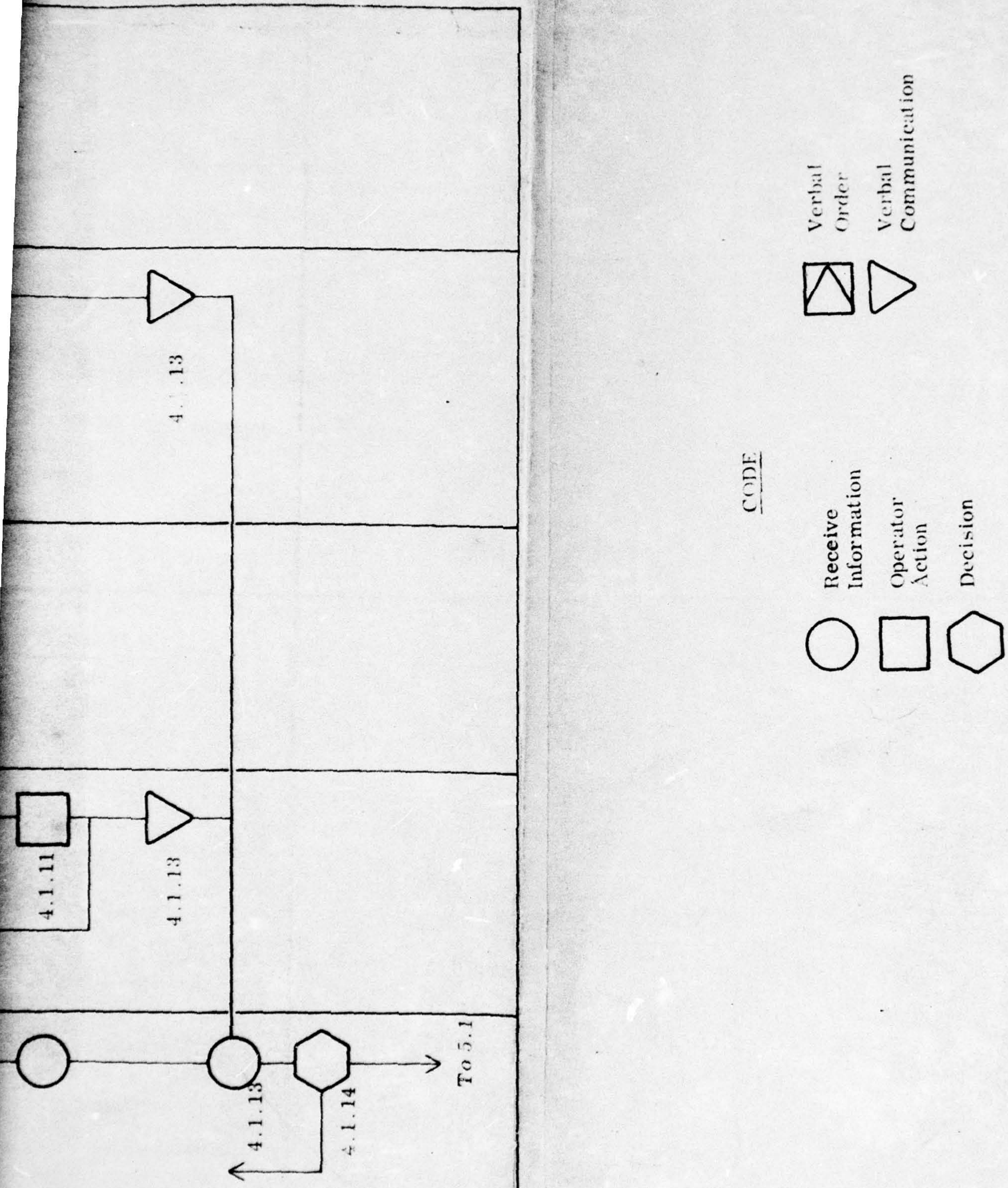
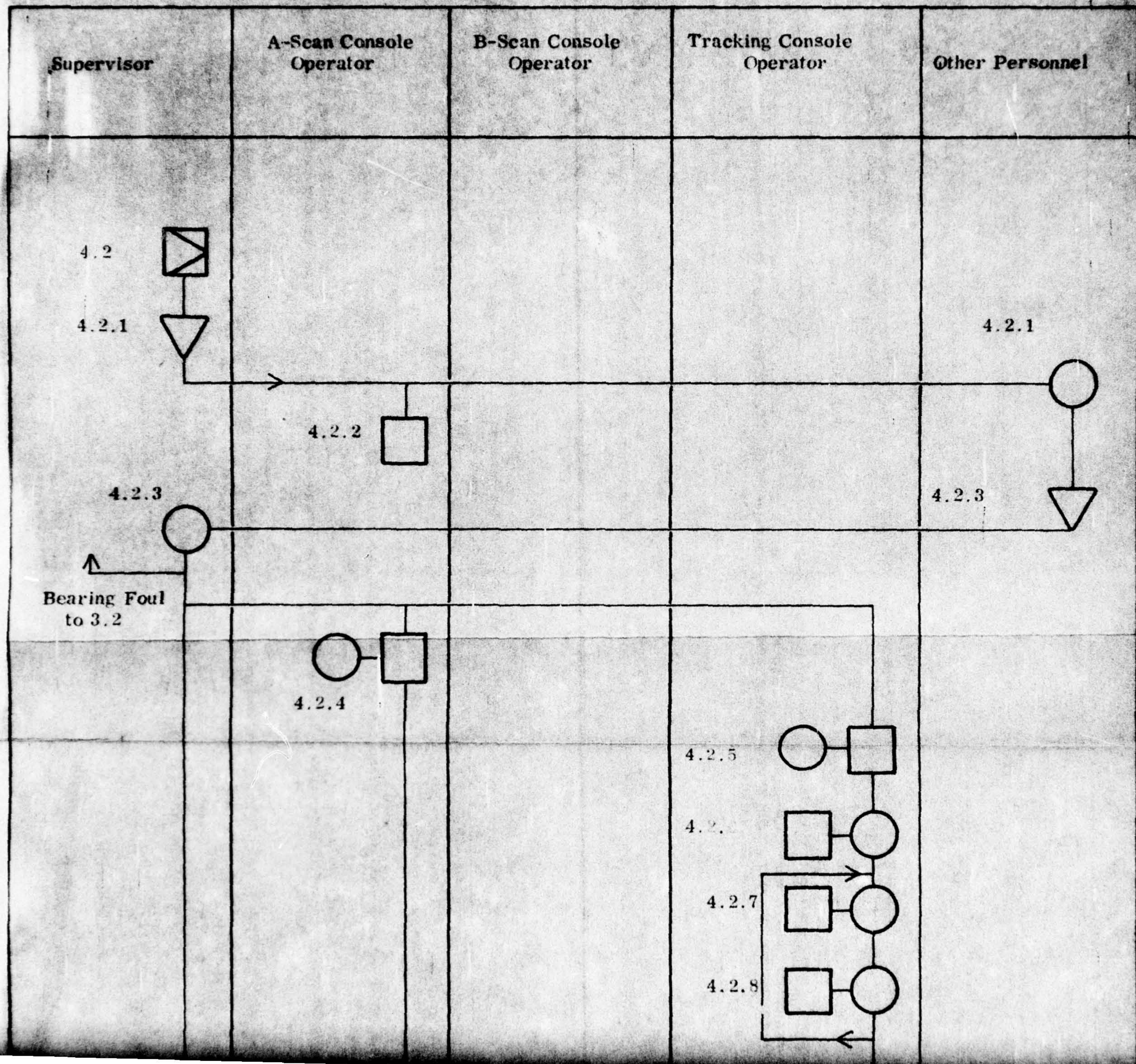
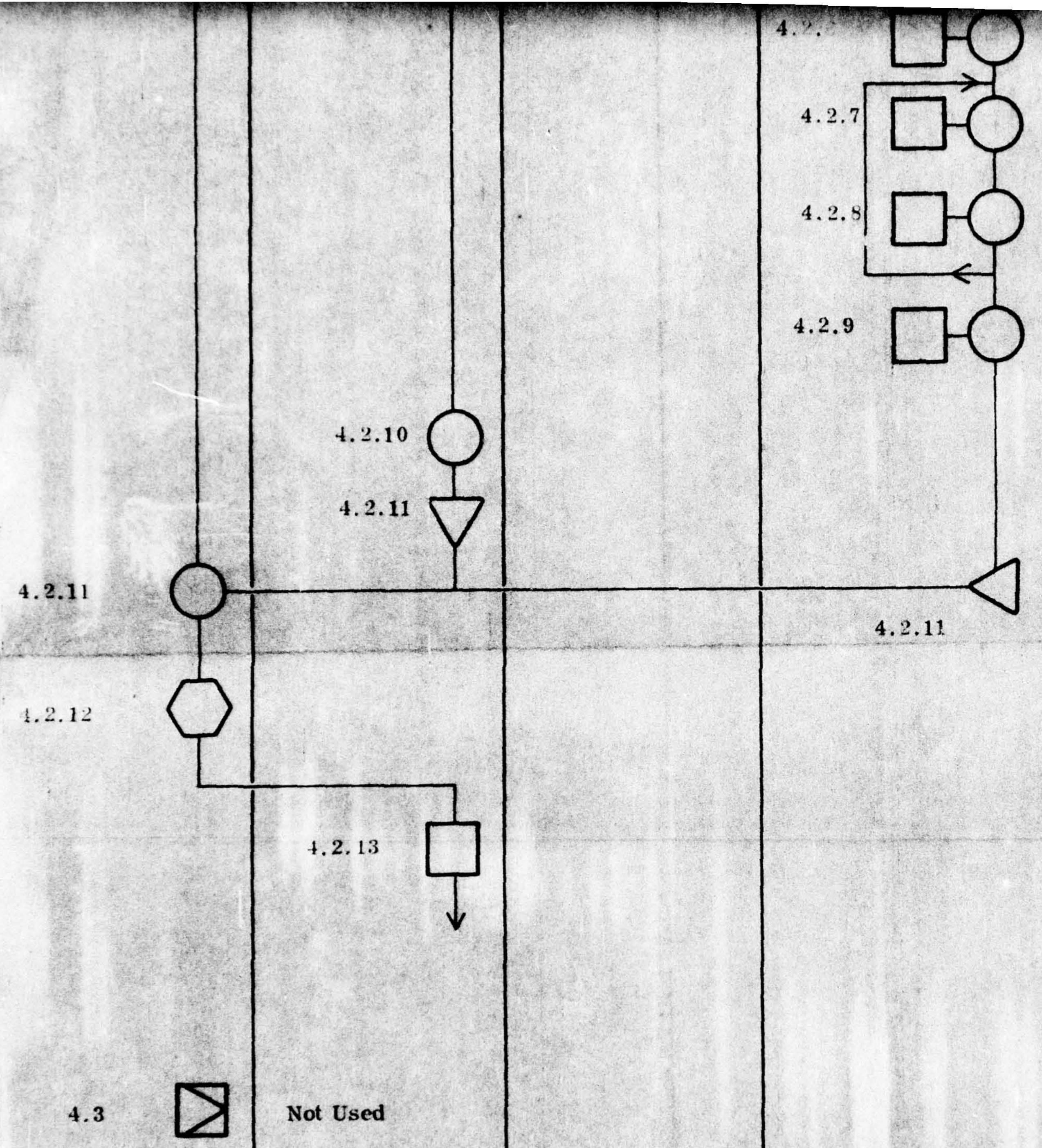


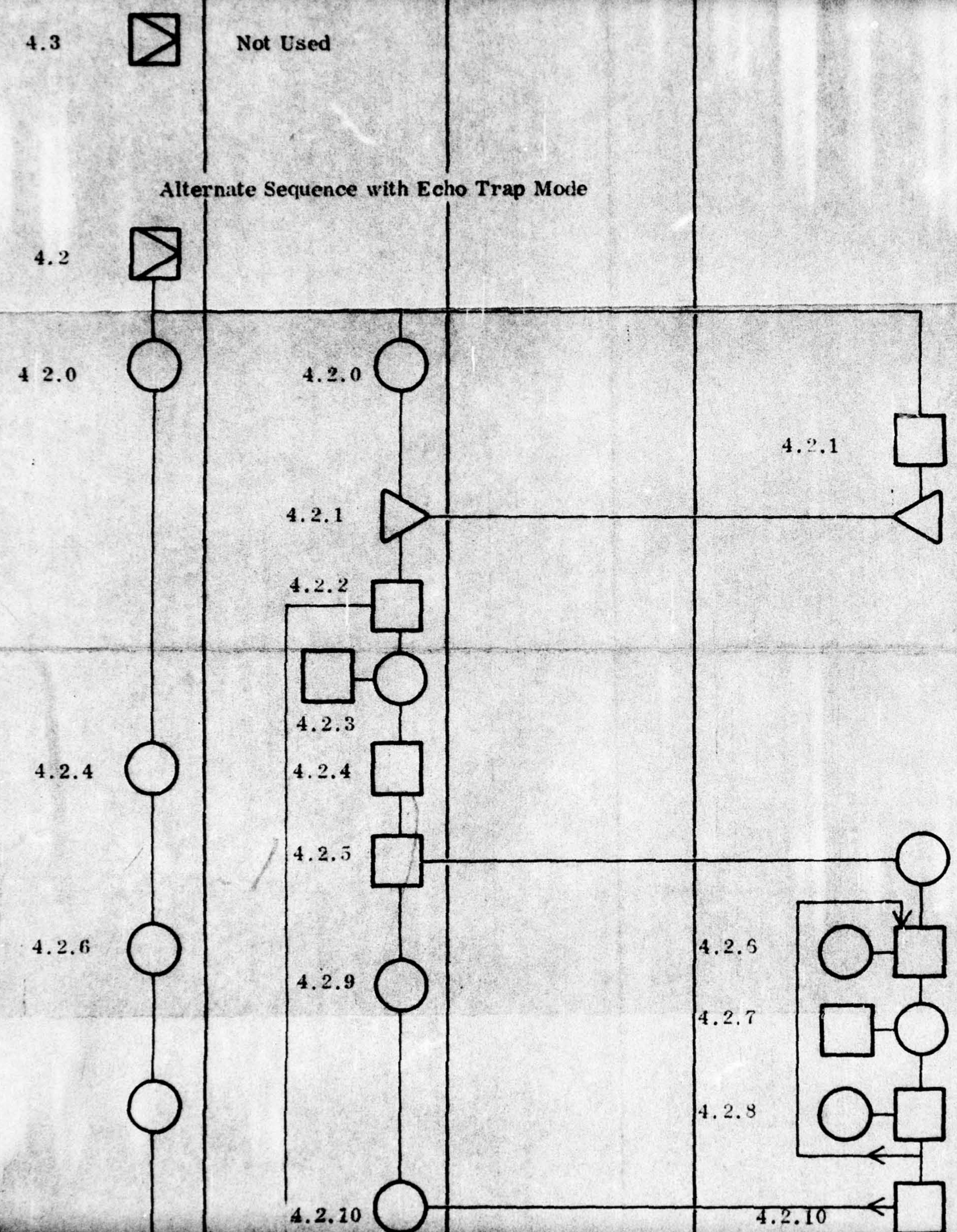
Figure 20. Operation Sequence Functional Diagram (Sheet 3 of 9)

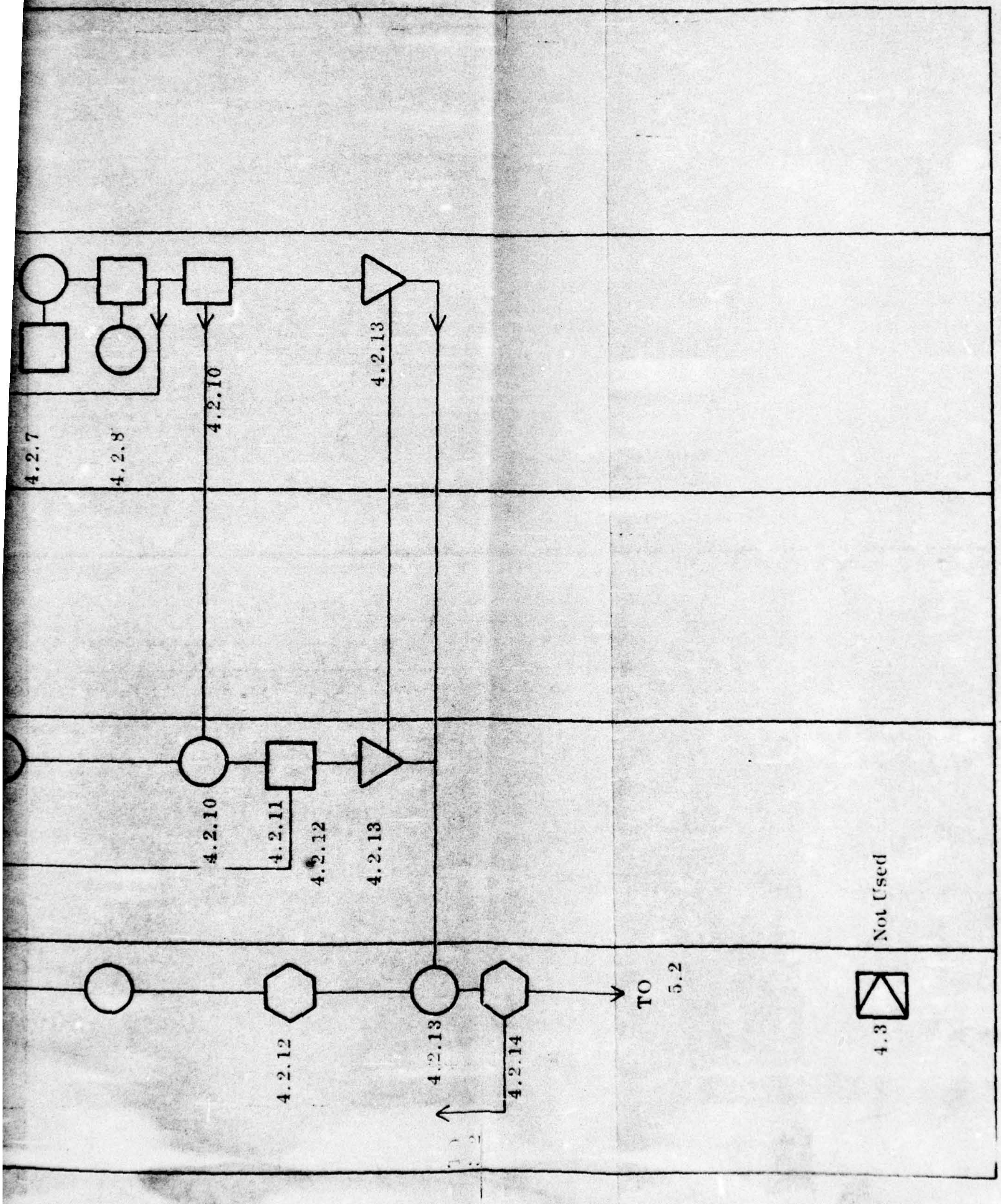


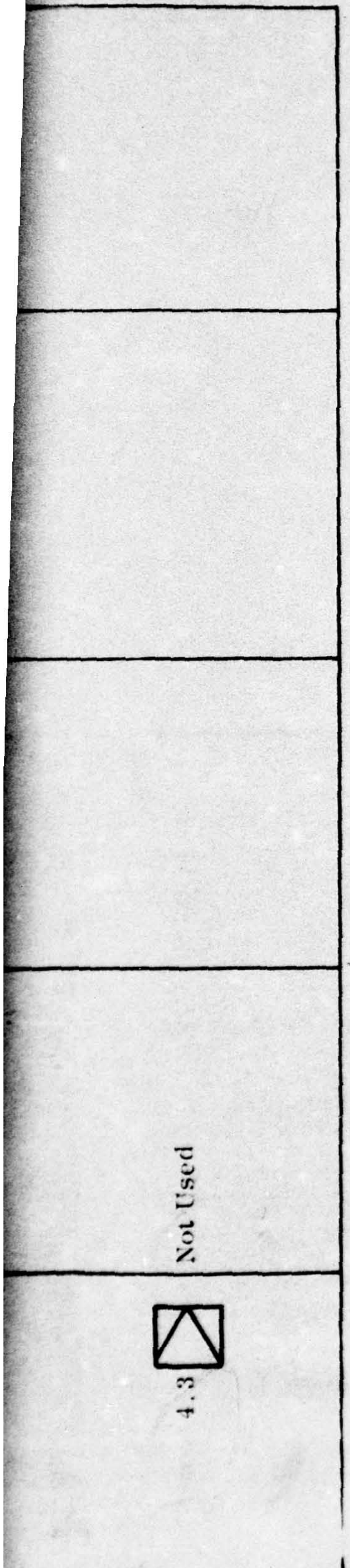
Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
4.2
4.2.1
4.2.1
4.2.2
4.2.3
4.2.3
Bearing Foul to 3.2
4.2.4
4.2.5
4.2.7
4.2.8



Alternate Sequence with Echo Trap Mode


4.3
Not Used
Alternate Sequence with Echo Trap Mode
4.2
4 2.0
4.2.0
4.2.1
4.2.1
4.2.2
4.2.3
4.2.4
4.2.4
4.2.5
4.2.6
4.2.6
4.2.7
4.2.8
4.2.9
4.2.10
4.2.10


4.2.7
4.2.8
4.2.10
4.2.13
4.2.10
4.2.11
4.2.12
4.2.13
4.2.12
4.2.13
4.2.14
TO 5.2
Not Used
4.3



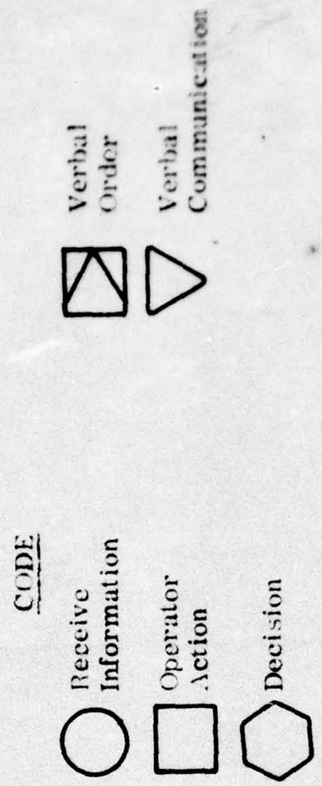
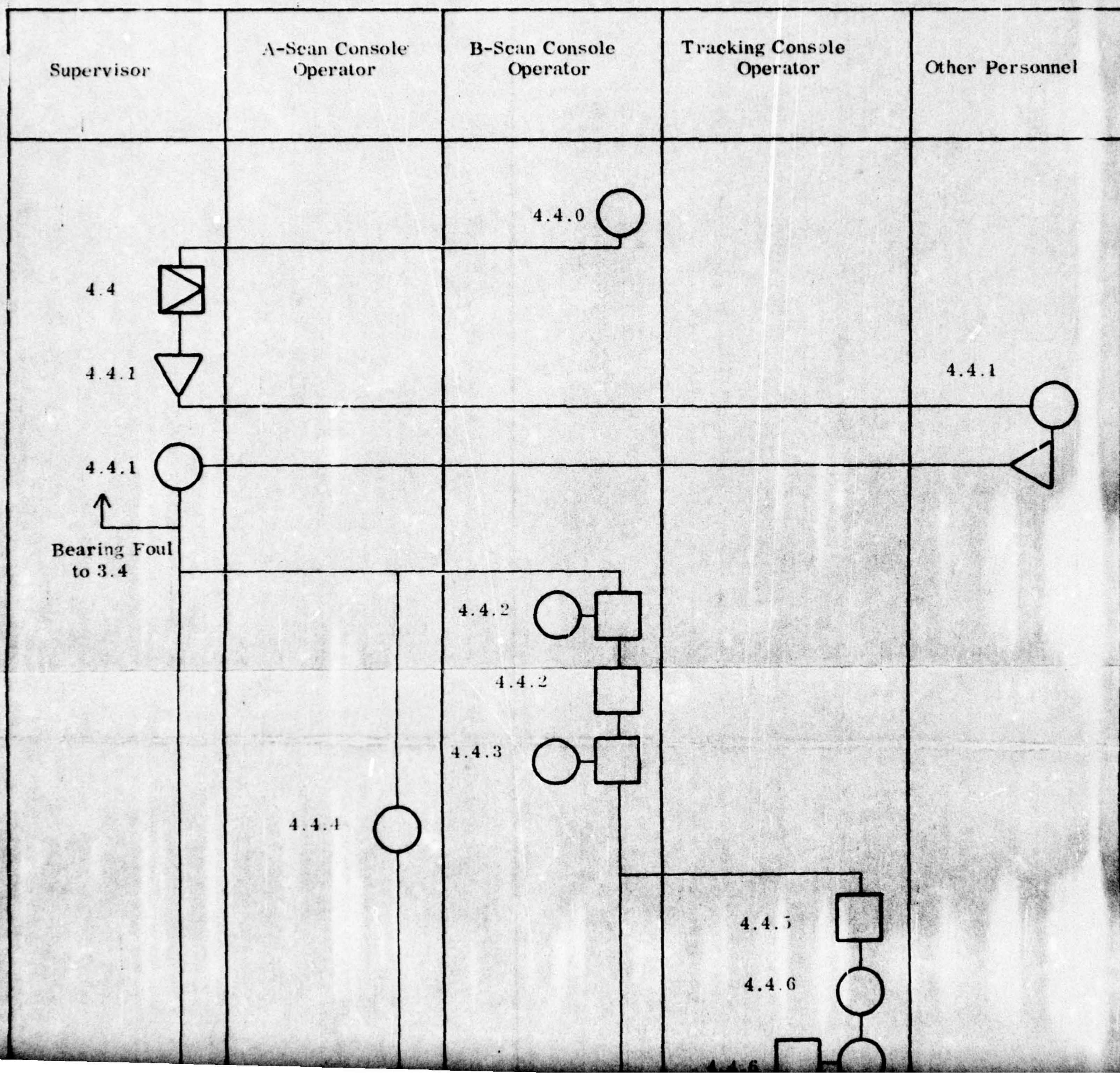
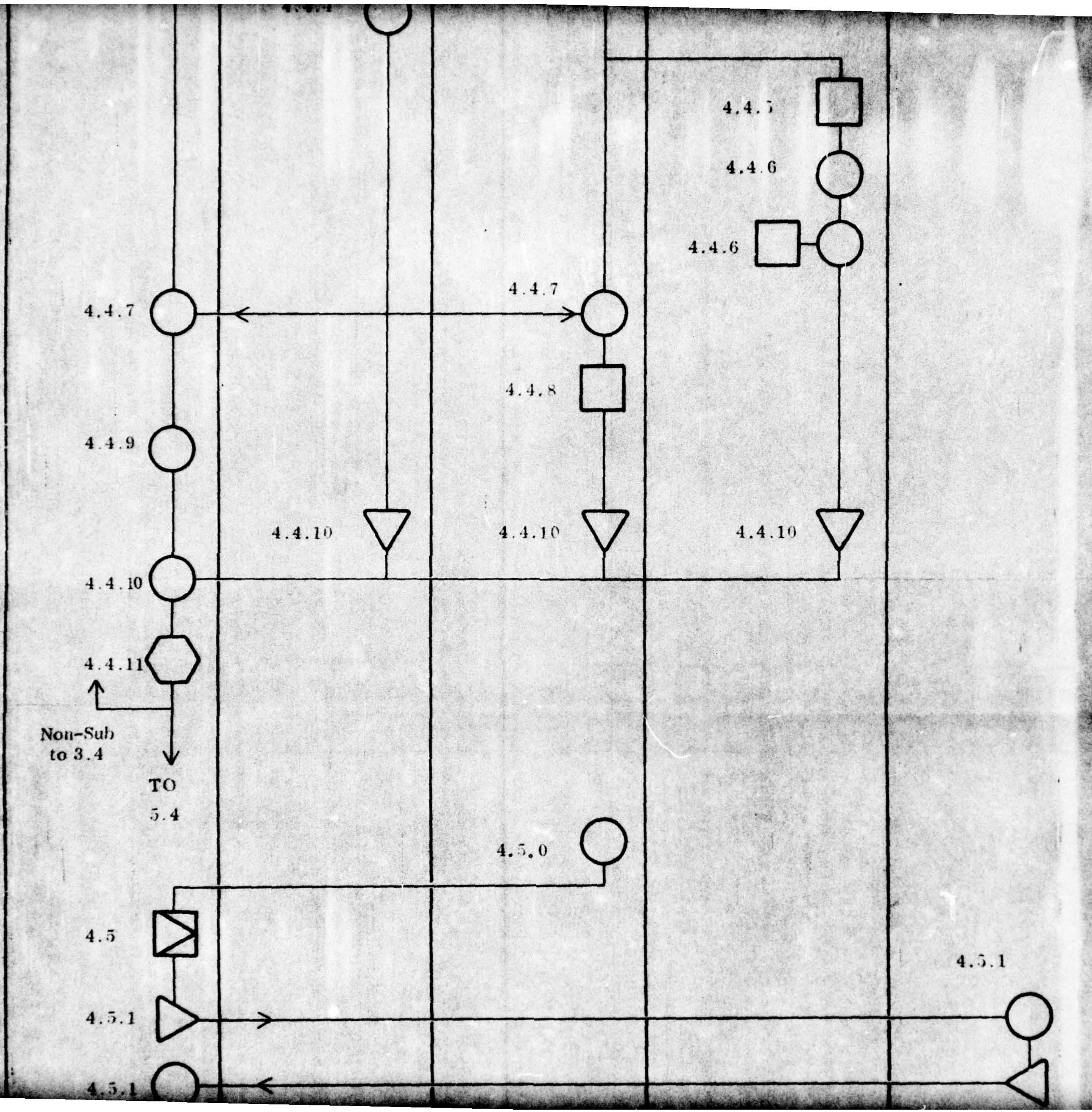


Figure 20. Operation Sequence Functional Diagram (Sheet 4 of 9)

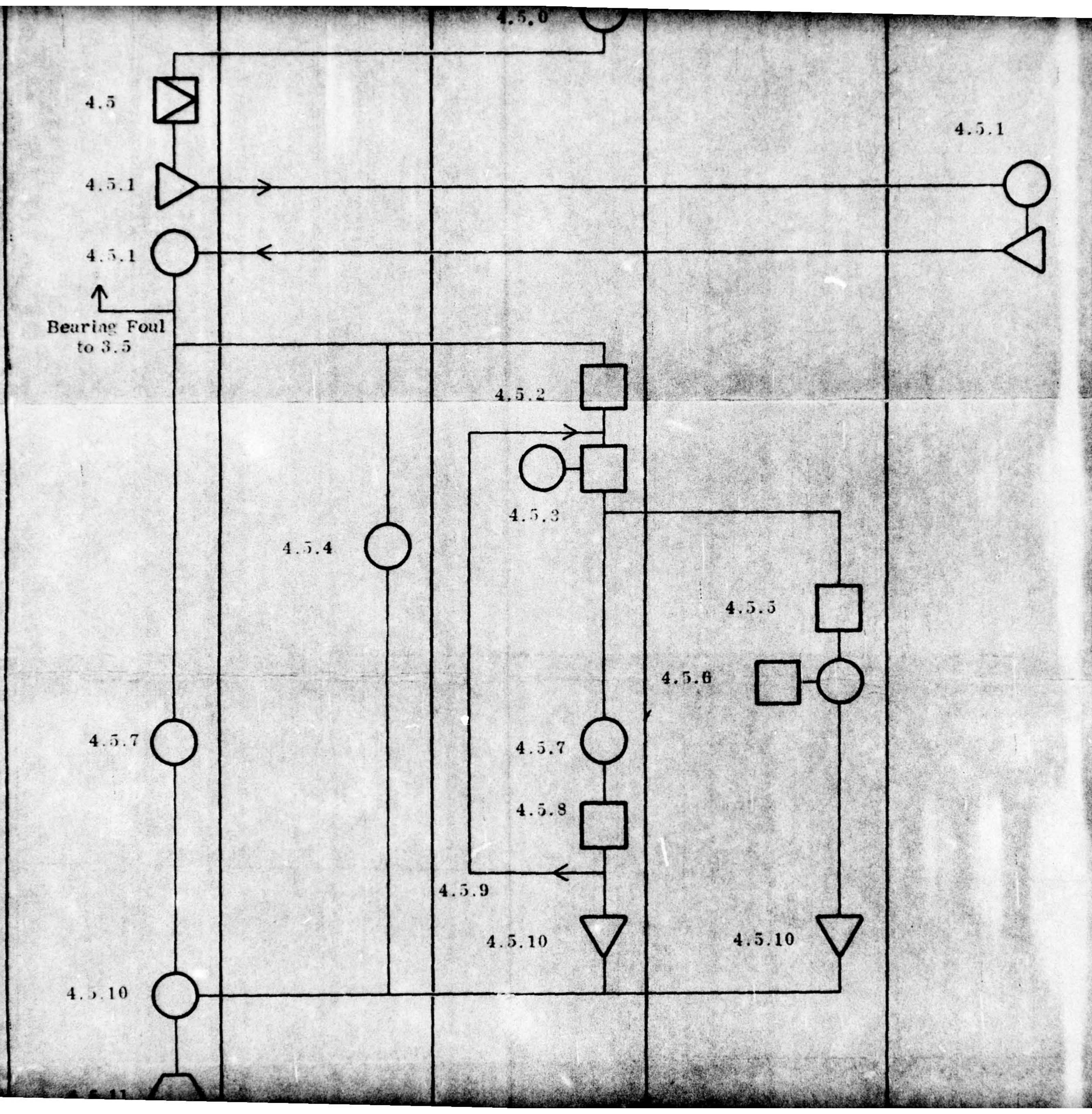
5

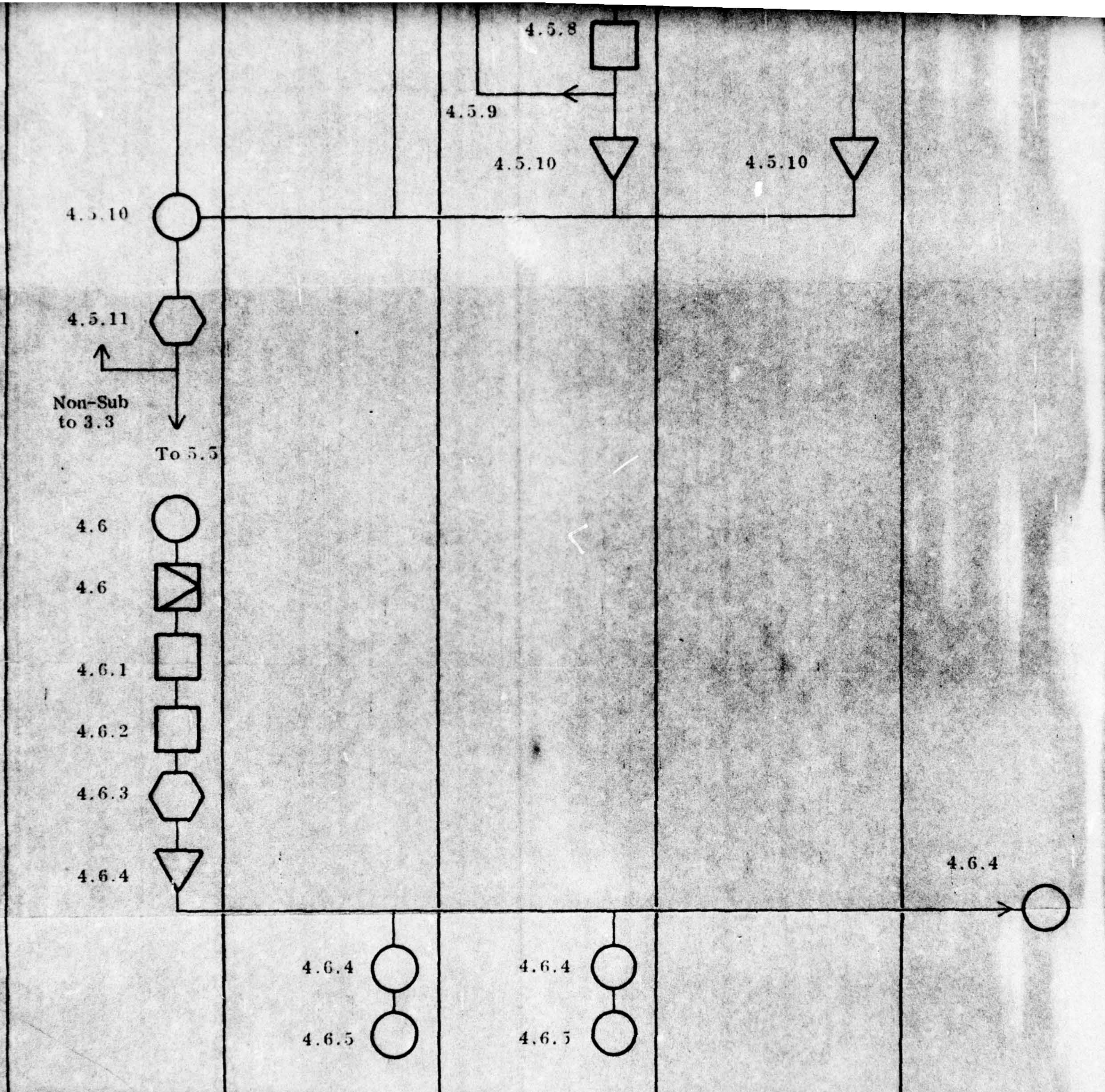


Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
4.4.0
4.4
4.4.1
4.4.1
4.4.1
Bearing Foul to 3.4
4.4.2
4.4.2
4.4.3
4.4.4
4.4.6



4.4.5
4.4.6
4.4.6
4.4.7
4.4.7
4.4.8
4.4.9
4.4.10
4.4.10
4.4.10
4.4.10
4.4.11
Non-Sub
to 3.4
TO
5.4
4.5.0
4.5
4.5.1
4.5.1
4.5.1


4.5.0
4.5
4.5.1
4.5.1
4.5.1
Bearing Foul
to 3.5
4.5.2
4.5.3
4.5.4
4.5.5
4.5.6
4.5.7
4.5.7
4.5.8
4.5.9
4.5.10
4.5.10
4.5.10



END BLOCK 4

UNCLASSIFIED

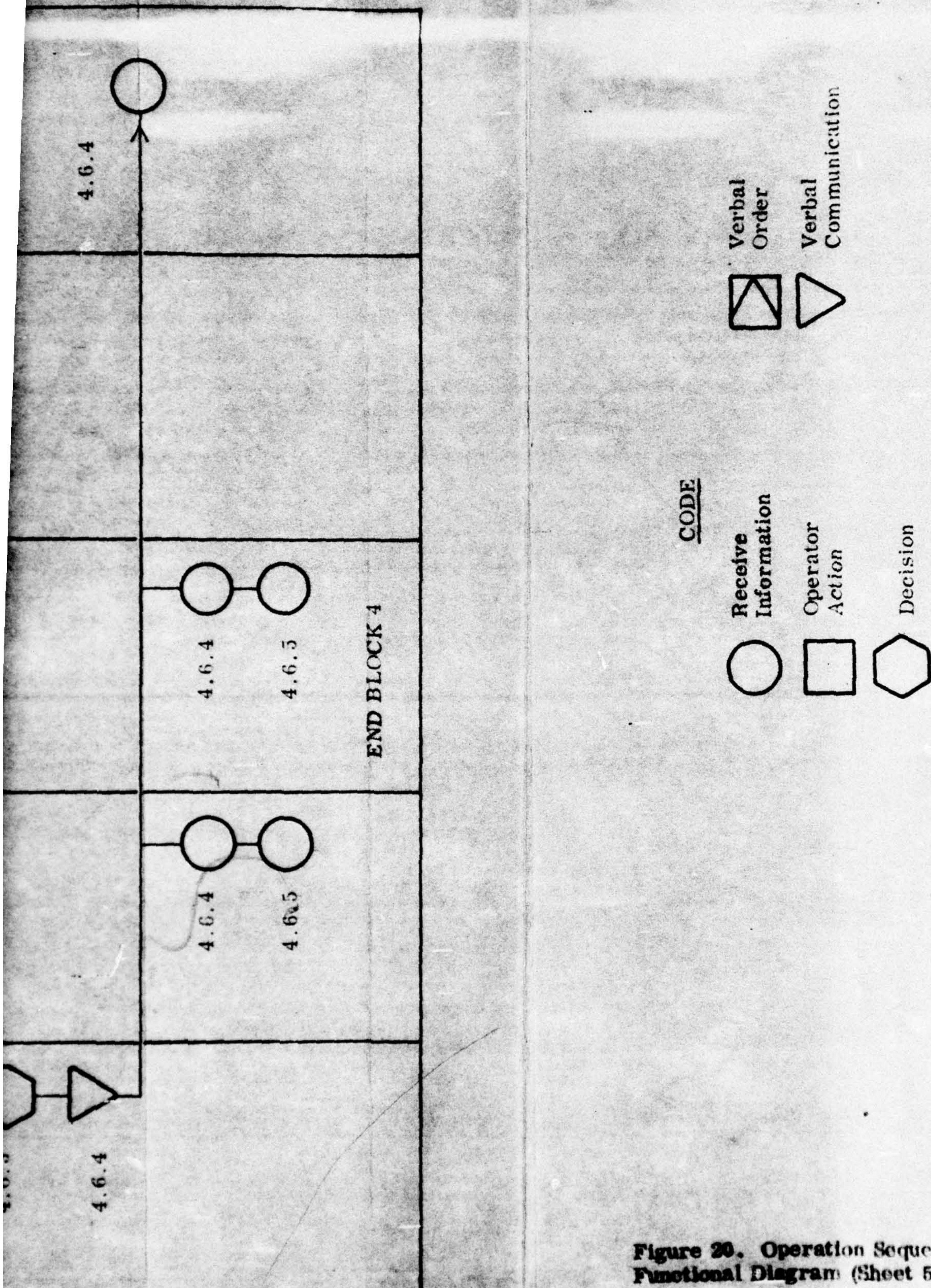
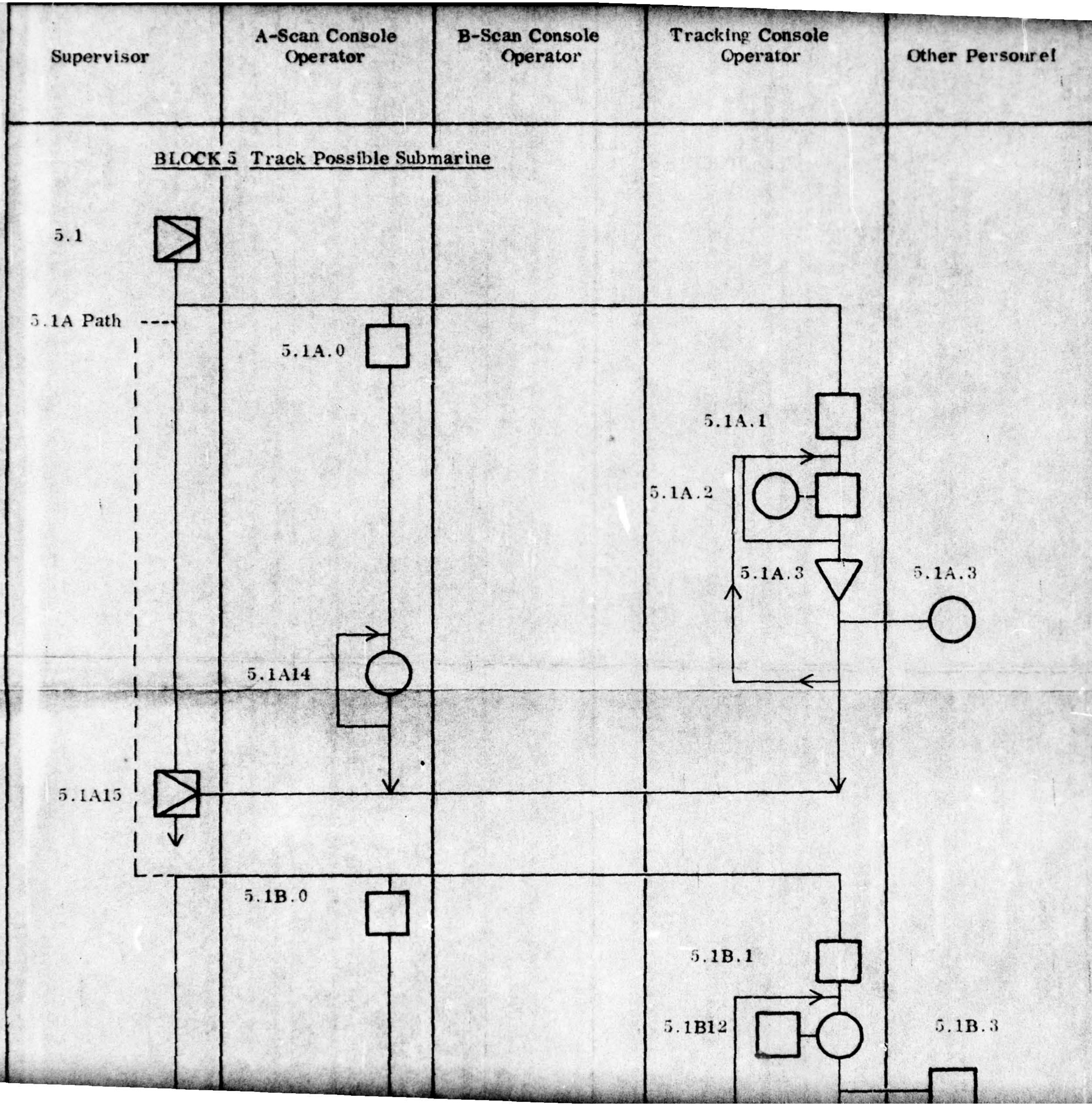
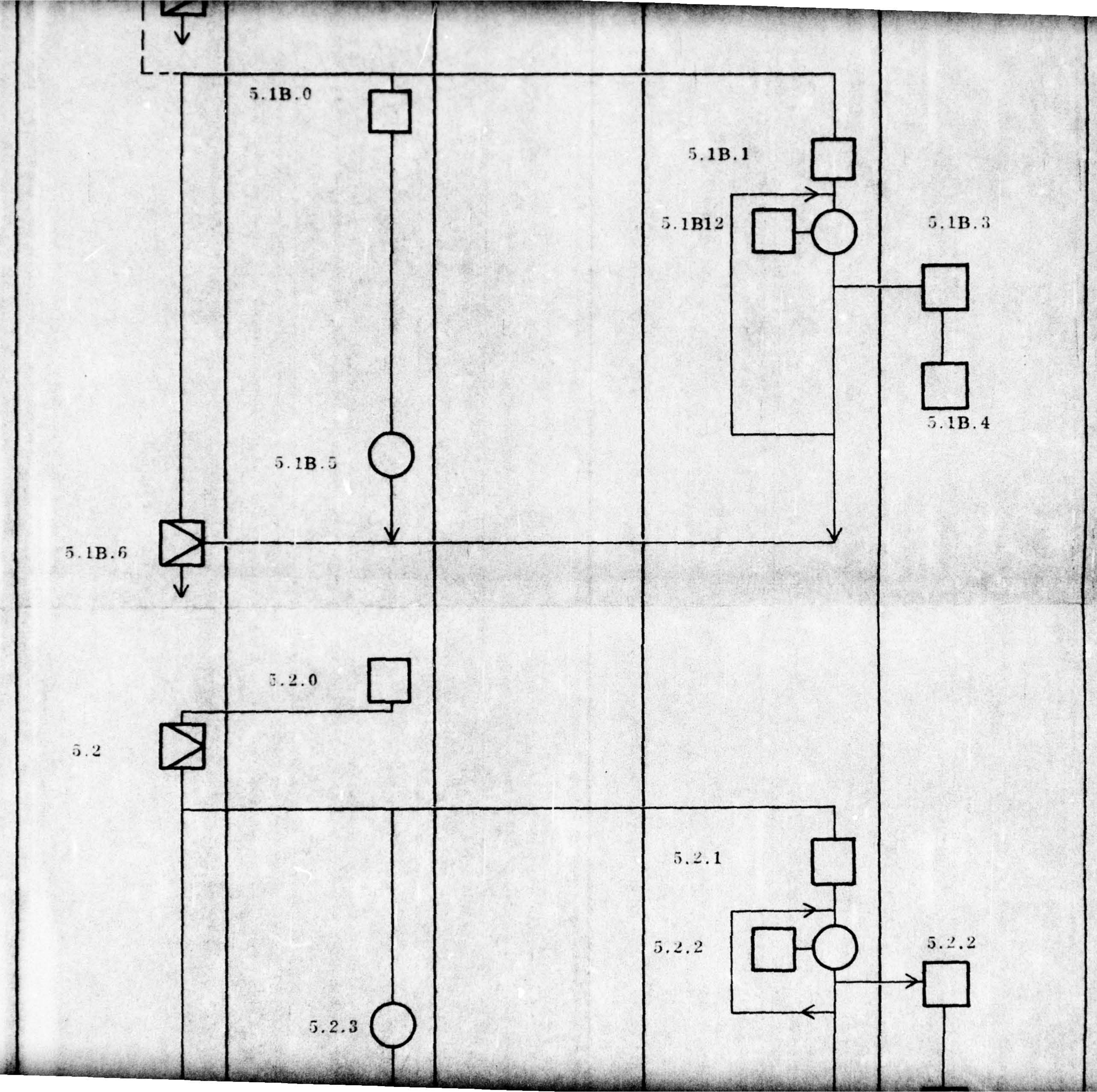
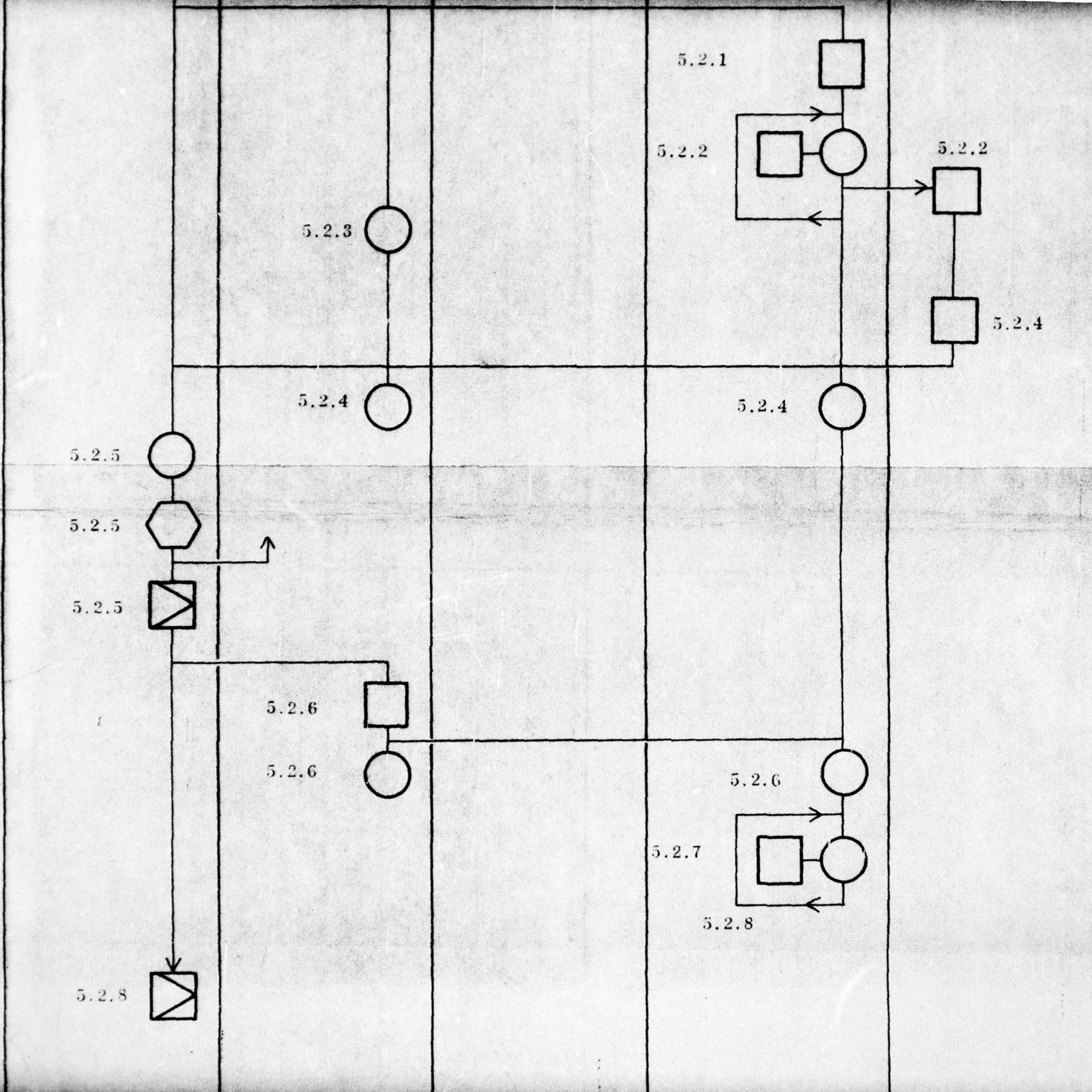
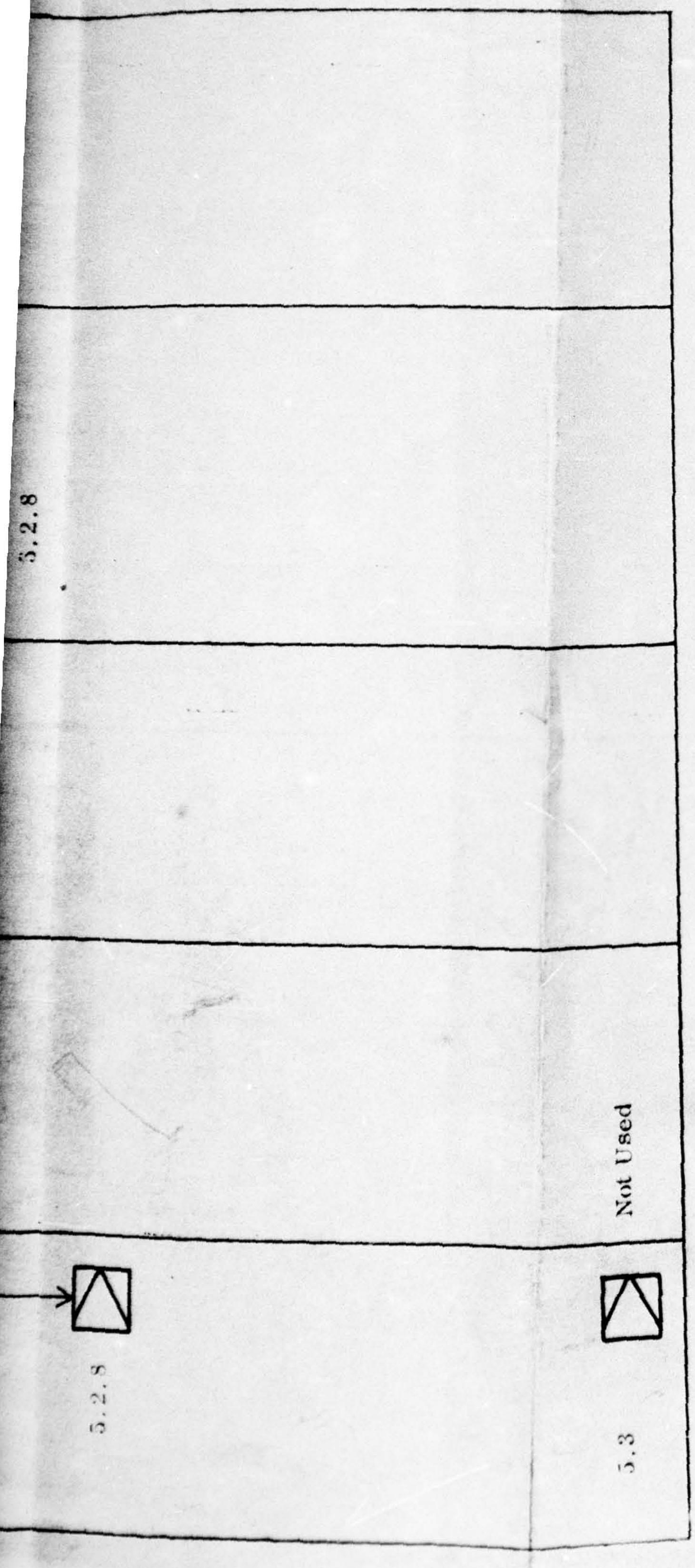


Figure 20. Operation Sequence
Functional Diagram (Sheet 5 of 9)


Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
BLOCK 5 Track Possible Submarine
5.1
5.1A Path
5.1A.0
5.1A.1
5.1A.2
5.1A.3
5.1A.3
5.1A14
5.1A15
5.1B.0
5.1B.1
5.1B12
5.1B.3


5.1B.0
5.1B.1
5.1B12
5.1B.3
5.1B.4
5.1B.5
5.1B.6
5.2.0
5.2
5.2.1
5.2.2
5.2.2
5.2.3


5.2.1
5.2.2
5.2.2
5.2.3
5.2.4
5.2.4
5.2.4
5.2.5
5.2.5
5.2.5
5.2.6
5.2.6
5.2.6
5.2.7
5.2.8
5.2.8



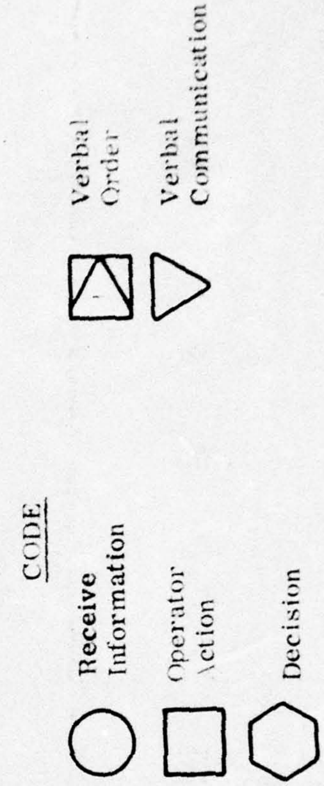
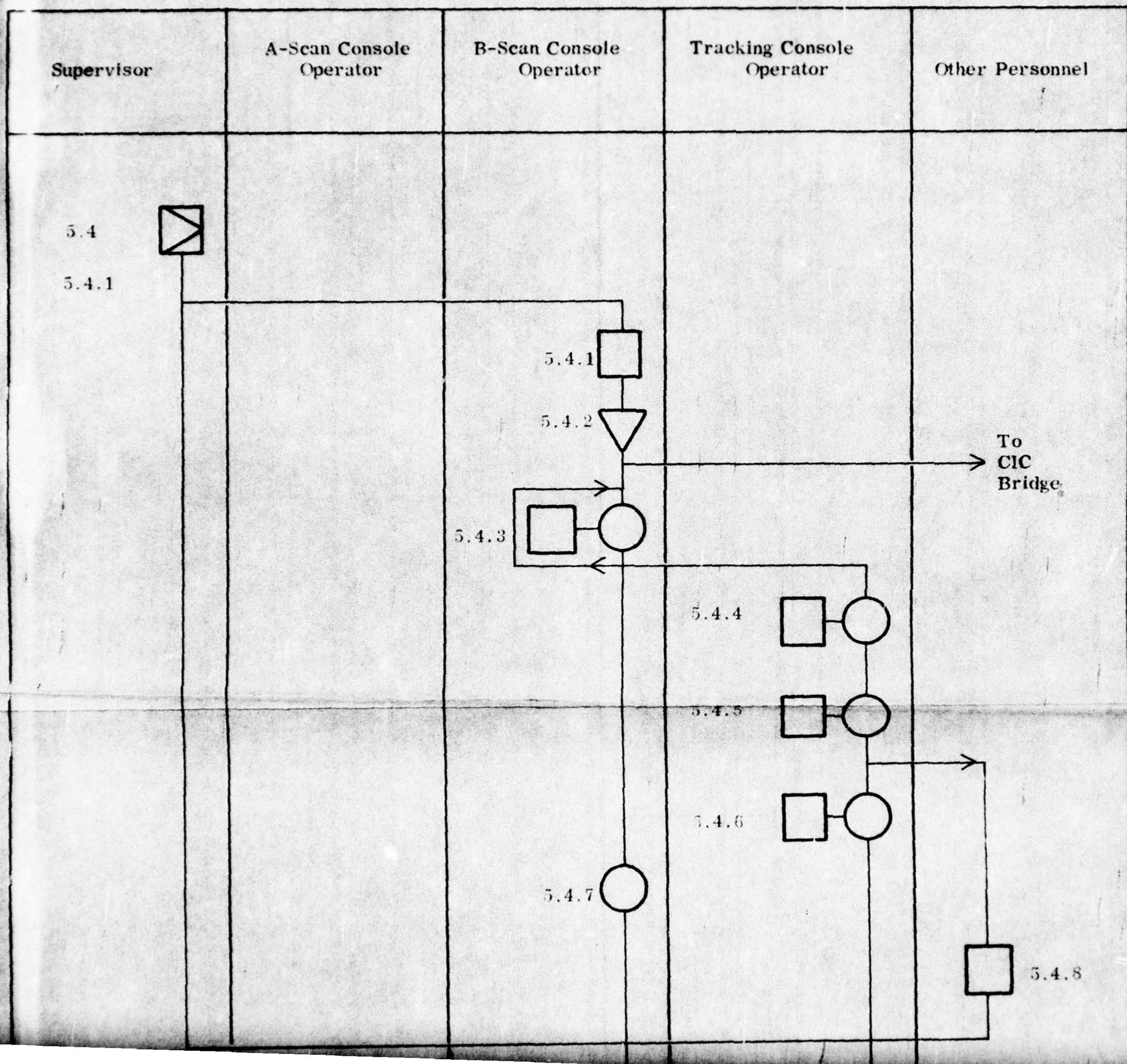
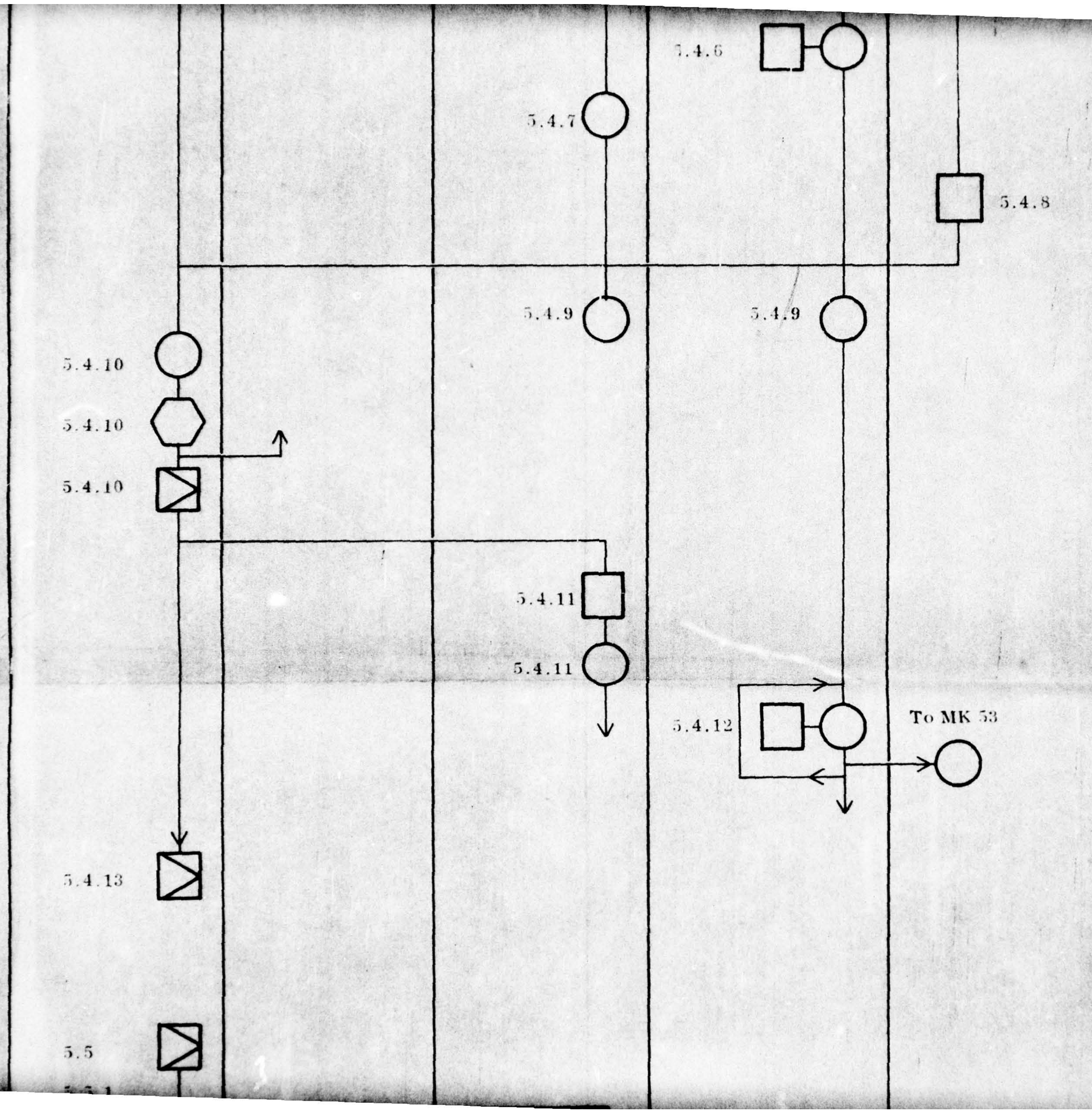
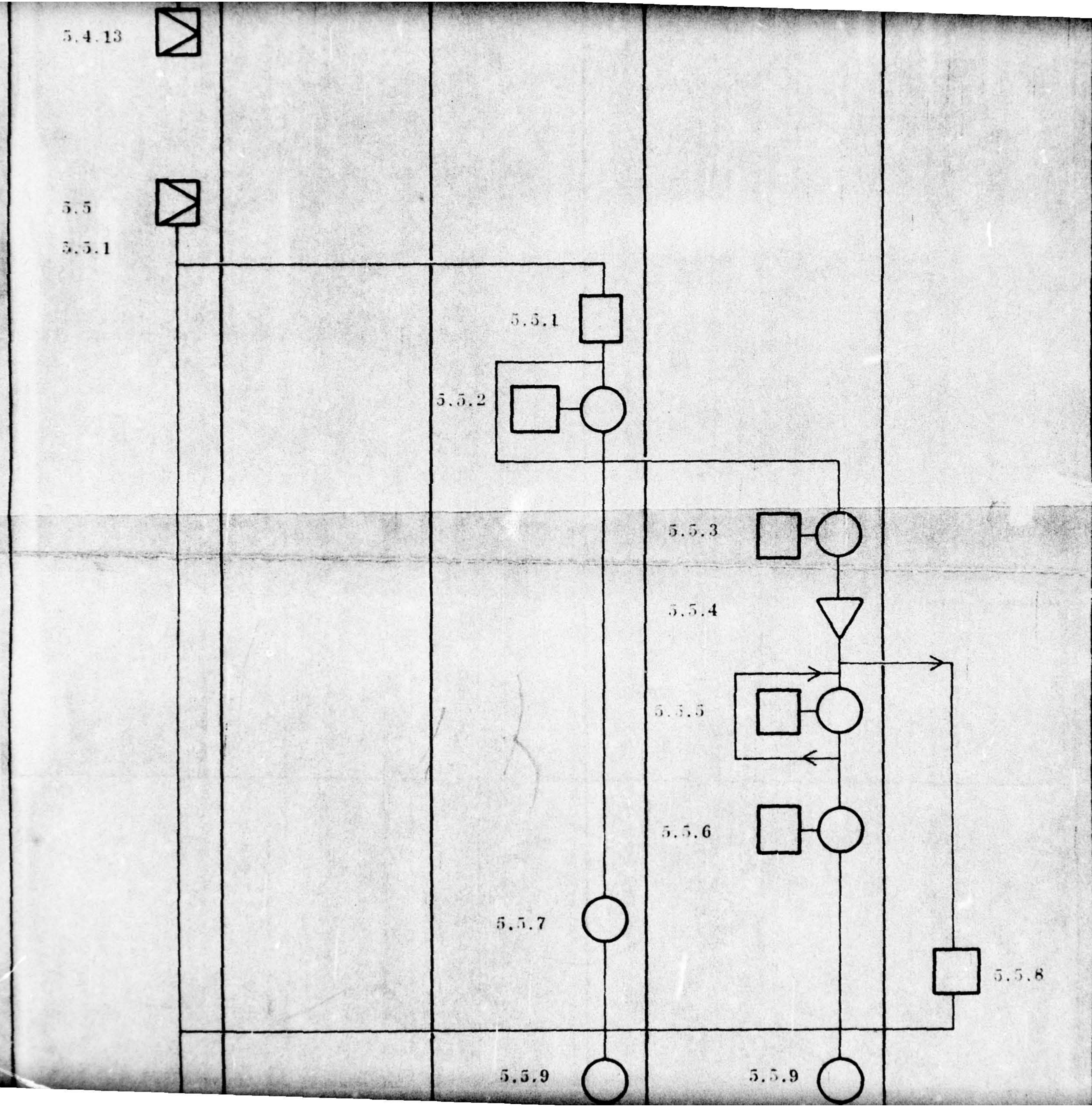


Figure 20. Operation Sequence Functional Diagram (Sheet 6 of 9)

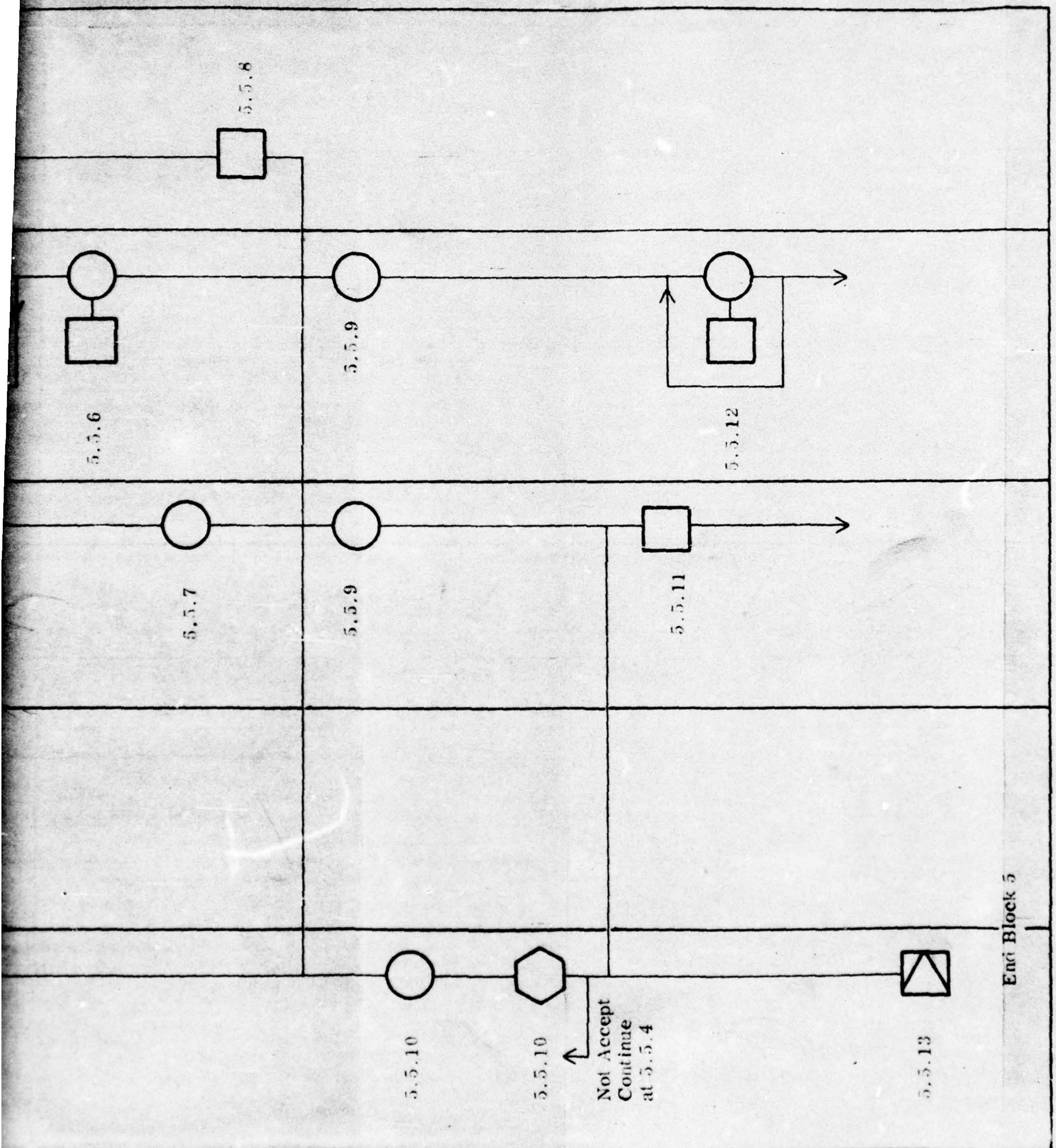

Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
5.4
5.4.1
5.4.1
5.4.2
To CIC Bridge
5.4.3
5.4.4
5.4.5
5.4.6
5.4.7
5.4.8

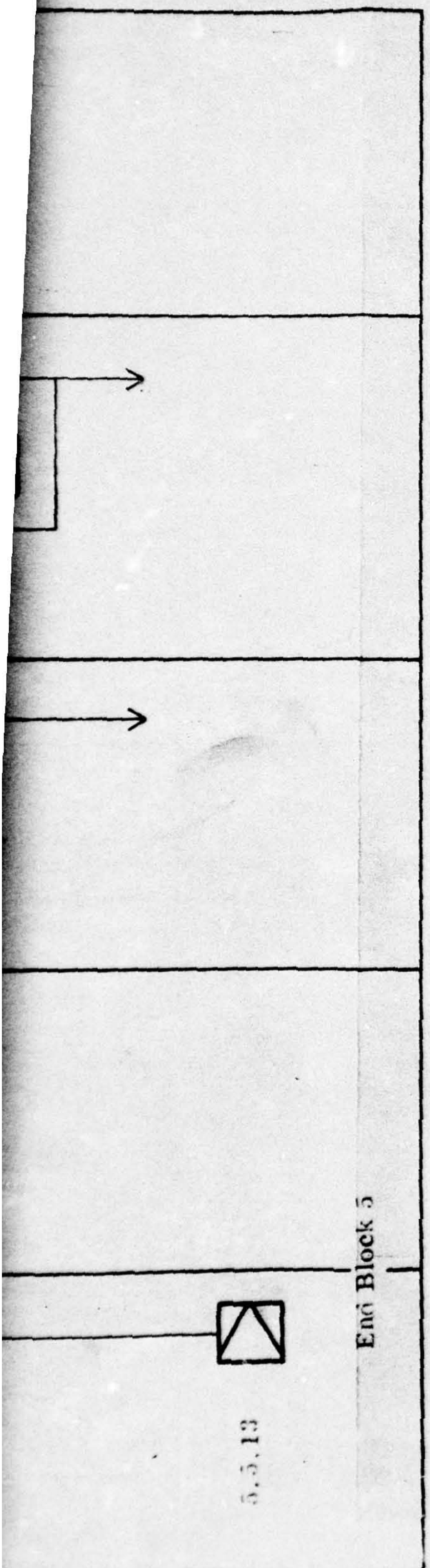


5.4.6
5.4.7
5.4.8
5.4.9
5.4.9
5.4.10
5.4.10
5.4.10
5.4.11
5.4.11
5.4.12
To MK 53
5.4.13
5.5


5.4.13
5.5
5.5.1
5.5.1
5.5.2
5.5.3
5.5.4
5.5.5
5.5.6
5.5.7
5.5.8
5.5.9
5.5.9

UNCLASSIFIED





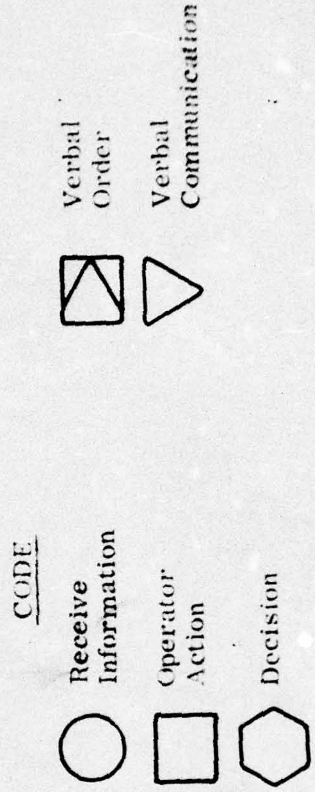
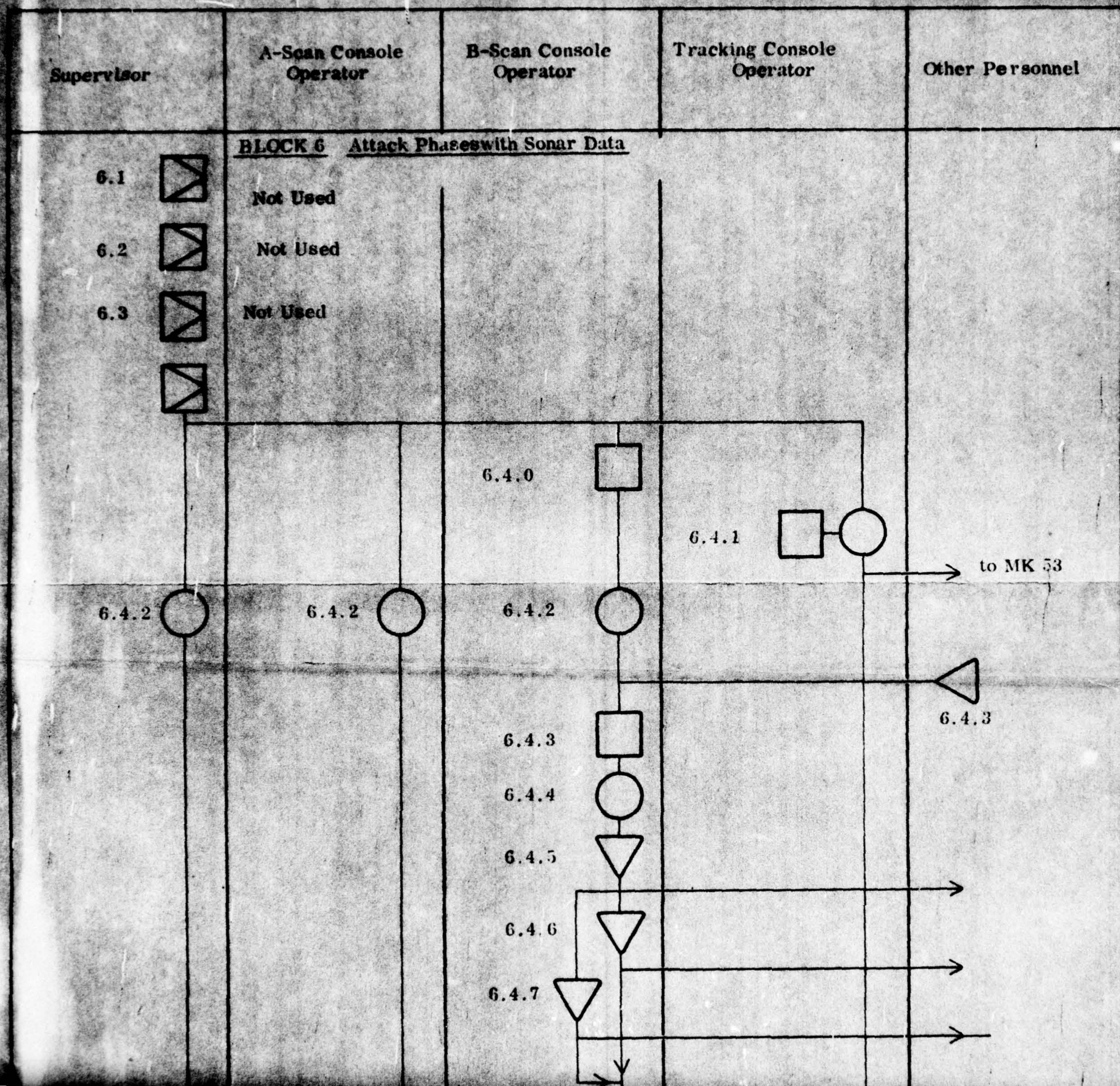
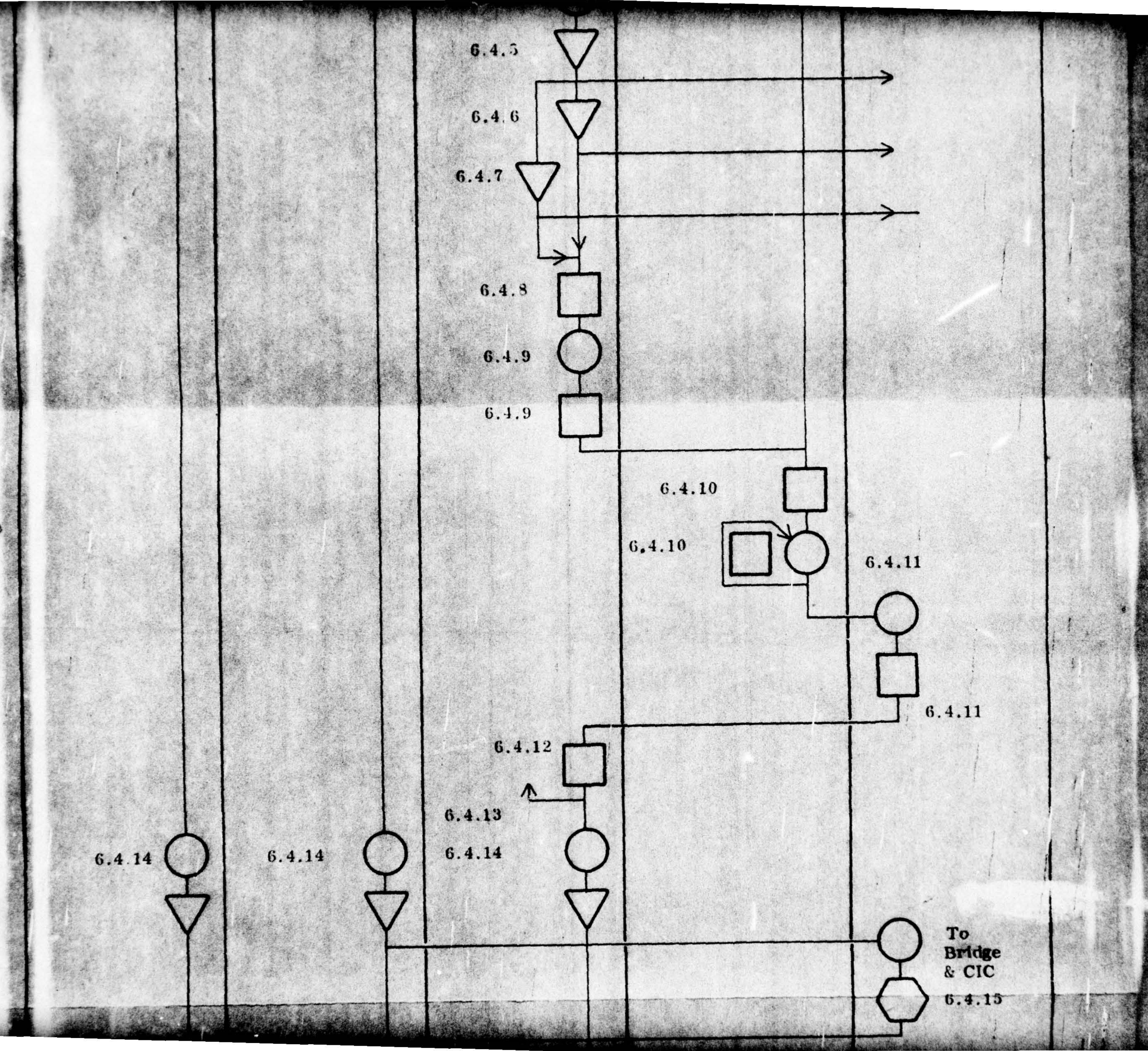


Figure 20. Operation Sequence Functional Diagram (Sheet 7 of 9)

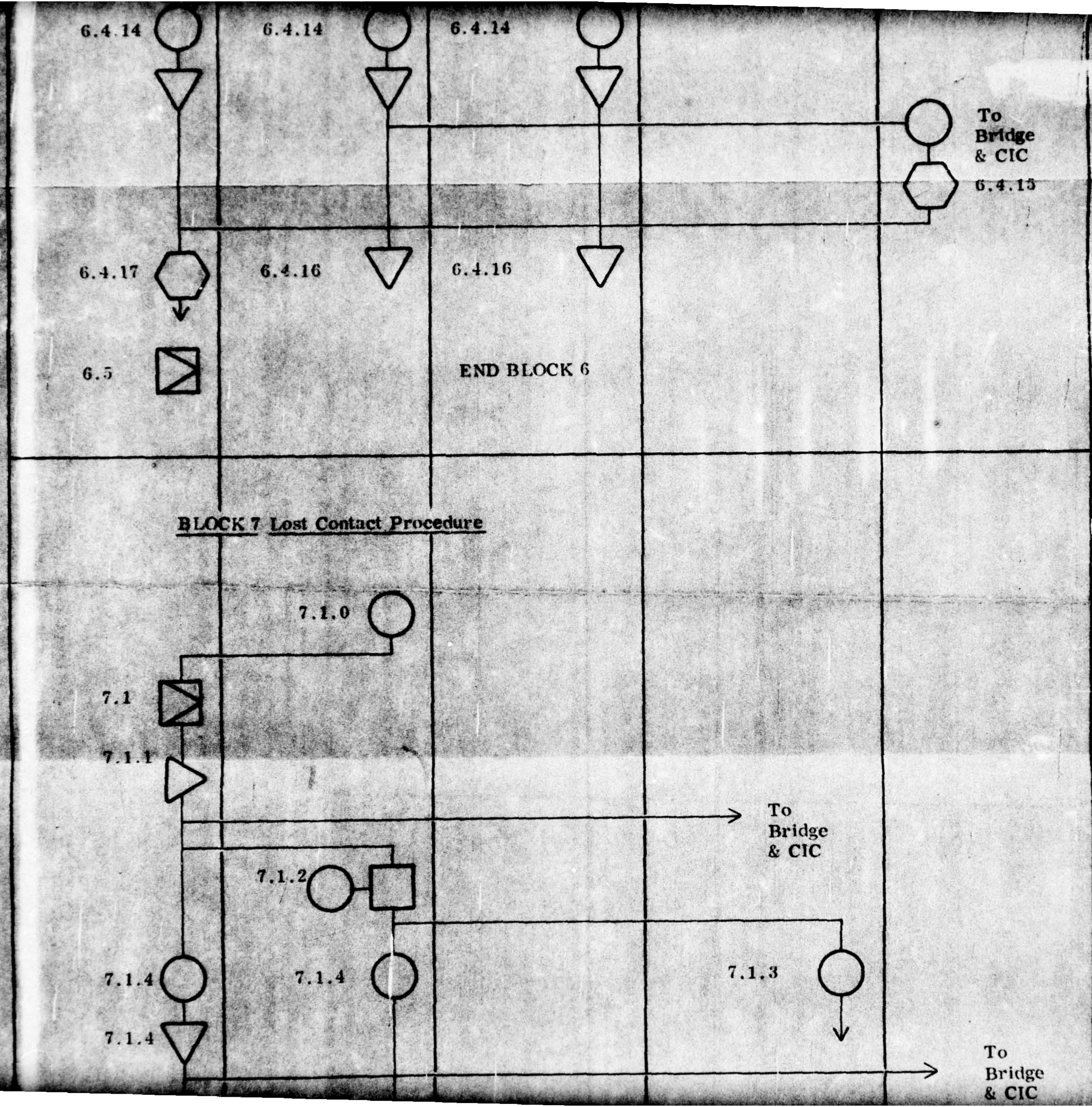
5

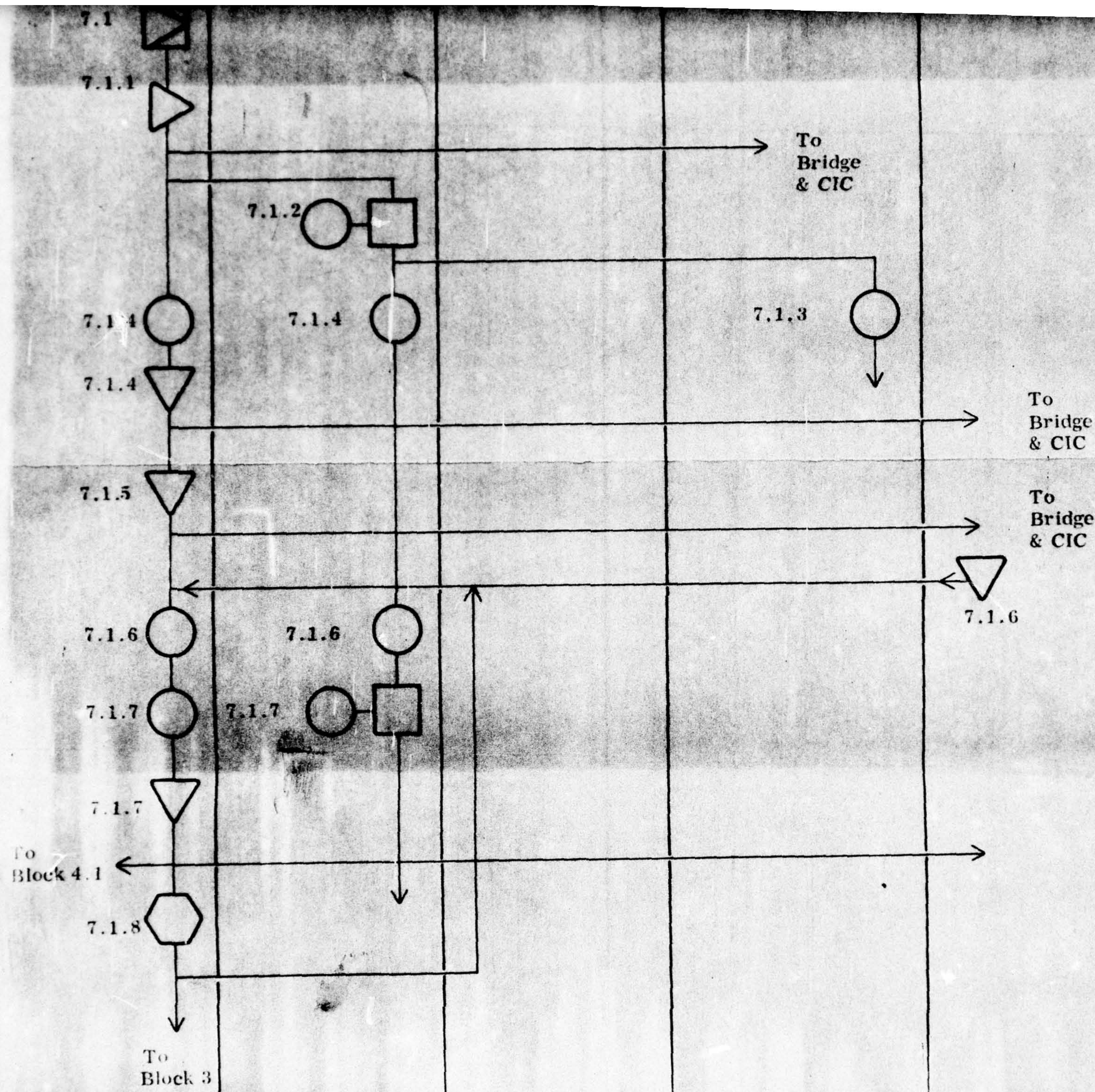


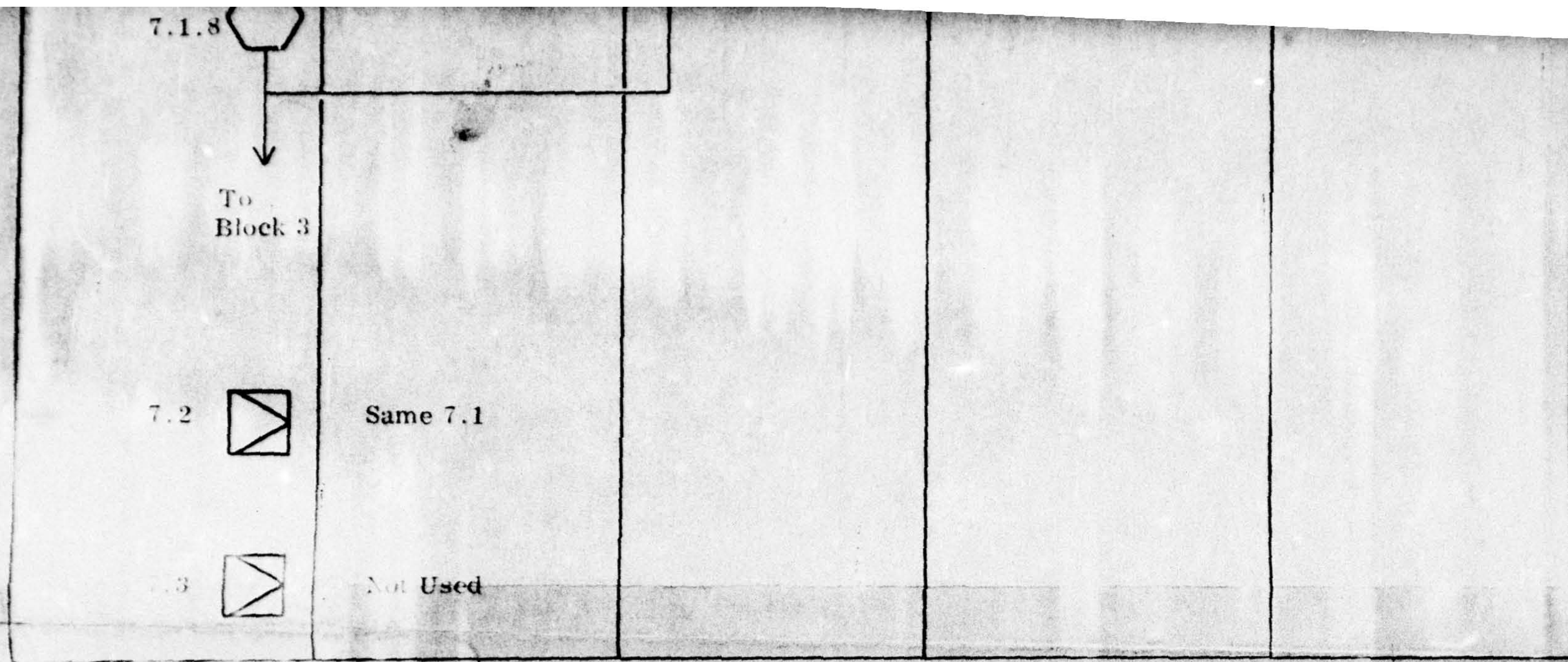
Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
BLOCK 6 Attack Phaseswith Sonar Data
6.1
Not Used
6.2
Not Used
6.3
Not Used
6.4.0
6.4.1
to MK 53
6.4.2
6.4.2
6.4.2
6.4.3
6.4.3
6.4.4
6.4.5
6.4.6
6.4.7



6.4.5
6.4.6
6.4.7
6.4.8
6.4.9
6.4.9
6.4.10
6.4.10
6.4.11
6.4.11
6.4.12
6.4.13
6.4.14
6.4.14
6.4.14
To Bridge & CIC
6.4.15


6.4.14
6.4.14
6.4.14
To Bridge & CIC
6.4.15
6.4.17
6.4.16
6.4.16
6.5
END BLOCK 6
BLOCK 7 Lost Contact Procedure
7.1.0
7.1
7.1.1
To Bridge & CIC
7.1.2
7.1.4
7.1.4
7.1.3
7.1.4
To Bridge & CIC


7.1
7.1.1
To Bridge & CIC
7.1.2
7.1.4
7.1.4
7.1.3
7.1.4
To Bridge & CIC
7.1.5
To Bridge & CIC
7.1.6
7.1.6
7.1.6
7.1.7
7.1.7
7.1.7
To Block 4.1
7.1.8
To Block 3



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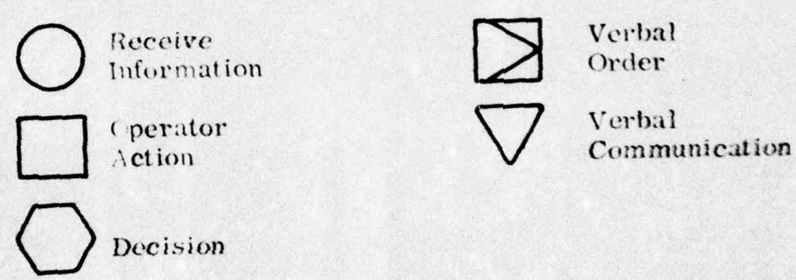
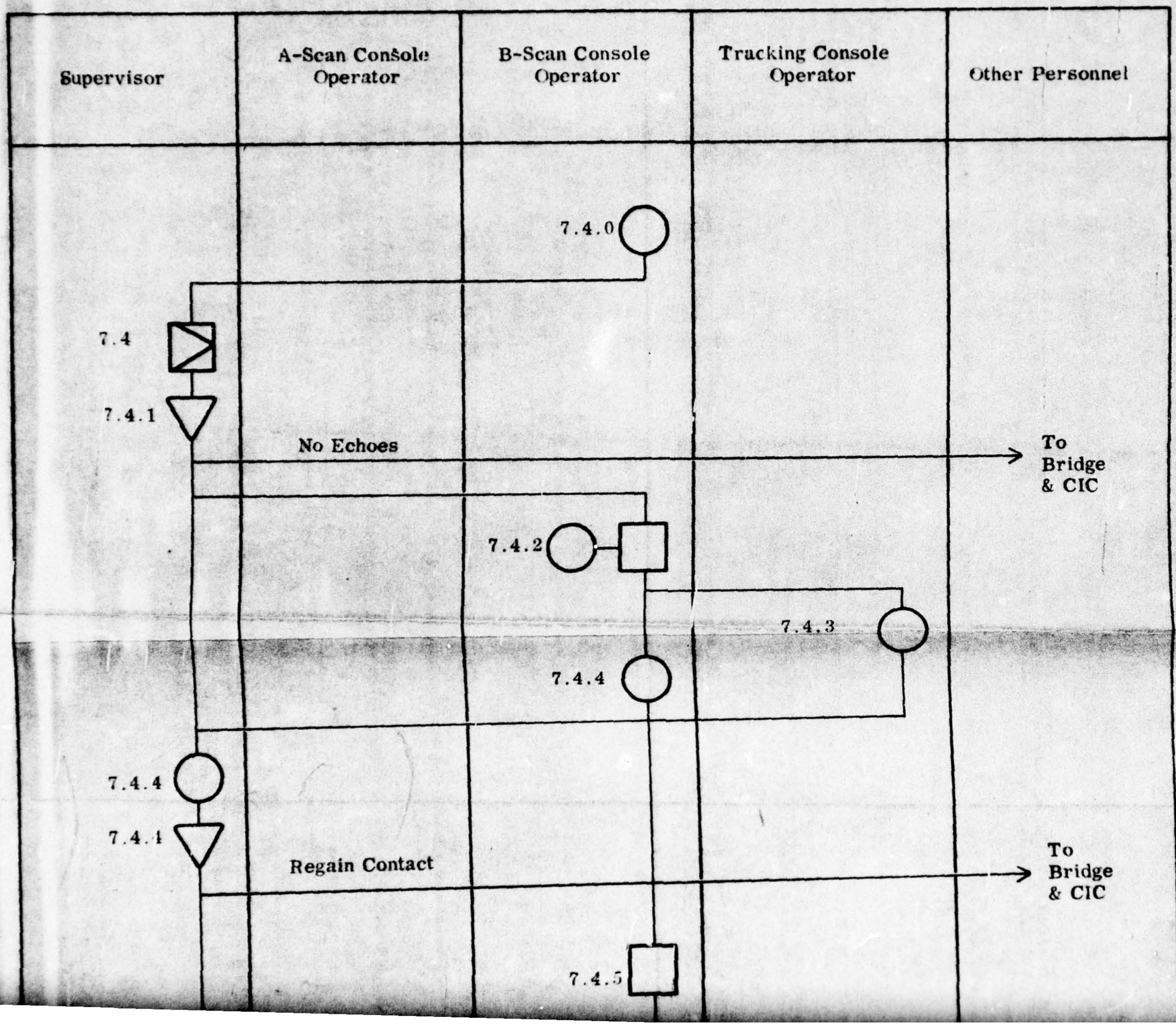
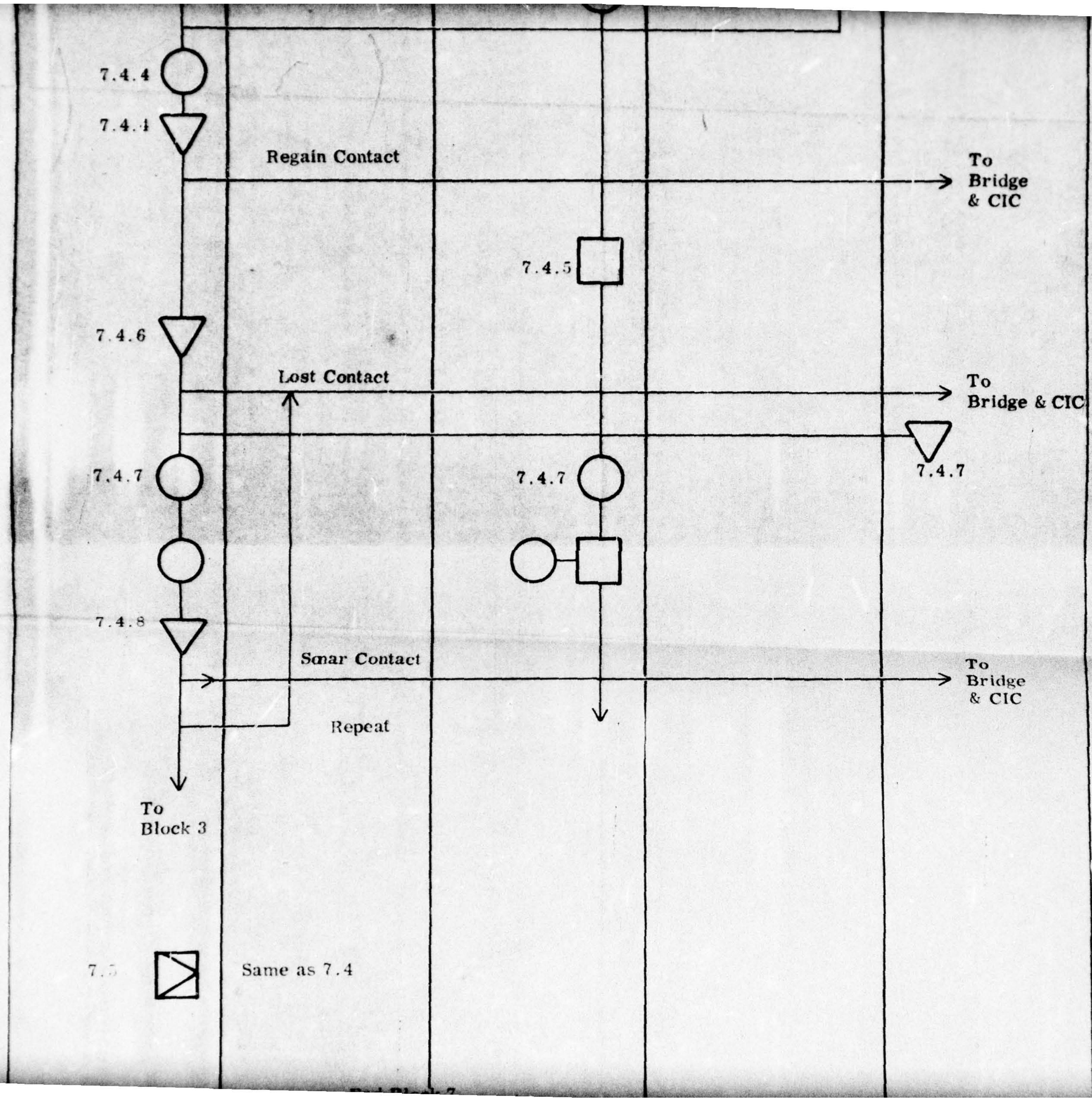


Figure 20. Operation Sequence Functional Diagram (Sheet 8 of 9)



Supervisor
A-Scan Console Operator
B-Scan Console Operator
Tracking Console Operator
Other Personnel
7.4.0
7.4
7.4.1
No Echoes
To Bridge & CIC
7.4.2
7.4.3
7.4.4
7.4.4
7.4.1
Regain Contact
To Bridge & CIC
7.4.5



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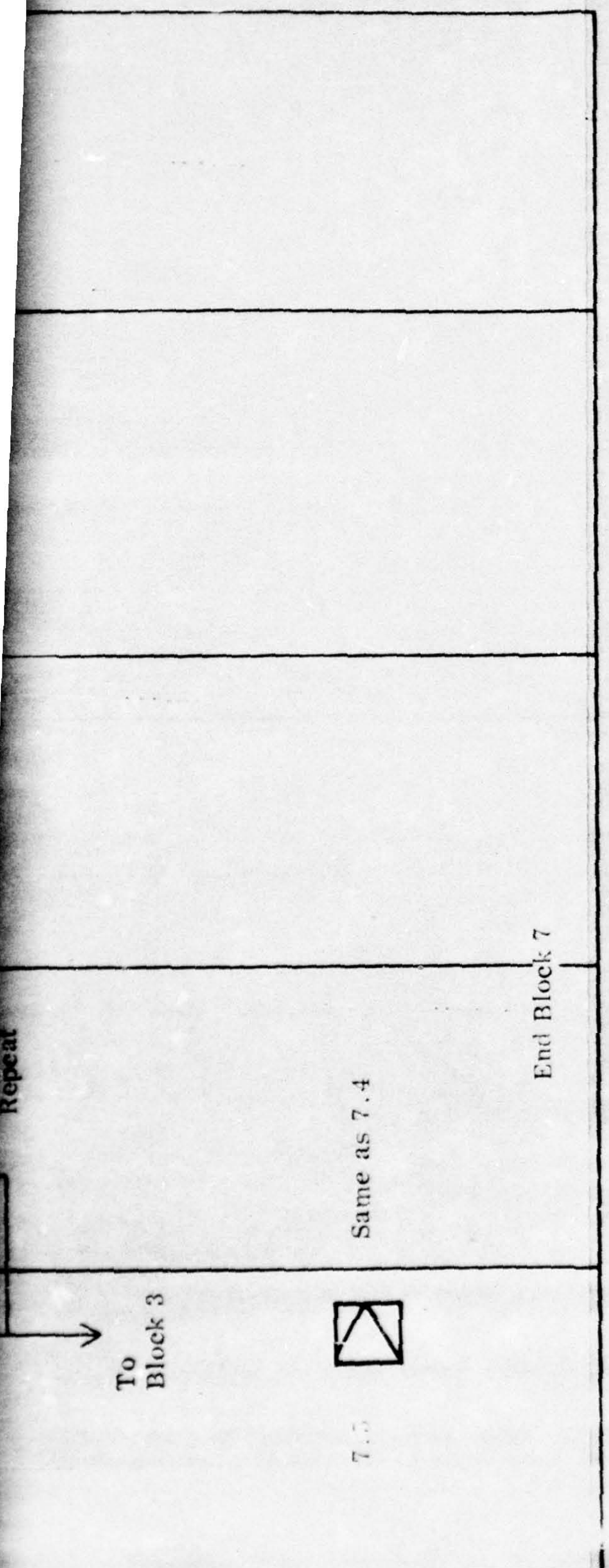

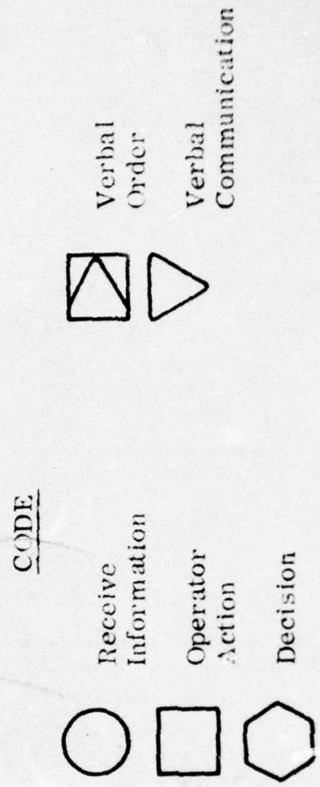

Figure 20. Operation Sequence Functional Diagram (Sheet 9 of 9)

APPENDIX E

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

ESTIMATED TIMES FOR TASKS

Prepared for:

U.S. NAVAL TRAINING DEVICE CENTER

Orlando, Florida

Prepared by:

HONEYWELL INC.
1200 East San Bernardino Road
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APPENDIX E

ESTIMATED TIMES FOR TASKS

This is a detailed time breakdown per task from Appendix B. Times are estimates only.

Block 1 - Compute Settings and Predict Performance

Task #	Time (seconds)	Remarks
1.1	60	
1.2	30	
1.3	60	
1.4	120	
1.5	30	
1.6	180	
1.7	30	
1.8	120	
1.9	30	
	10 minutes	

Block 2 - Set Up and Check Out Equipment

2.1	60	
2.2	240	Combined operation with 2.5
2.3	60	
2.4	60	
2.5	180	Variable depending on trials required
2.6	0	
	10 minutes (typical time)	

Block 3 - Conduct Search

Continuous repetitive activity, interrupted when a consistent echo is detected and contact phase begins as in Block 4.

3.1 CZ mode cycle - 3 pings per 78 seconds approximately. Each ping is 10[illegible] ms in total length.
3.2 BB mode cycle - 1 ping per 20-35 seconds dependent on bottom depth and depression angle. Each ping is 3000 ms in total length; for example, 20° depression angle, 2000 fathom bottom, 1 ping = 29 seconds.
3.3 Not used.
3.4 ODT mode - cycle rate variable 6-30 seconds dependent on range; for example, 5000 yards at 100 ms ping length = 6 seconds; 24,000 yards at 100 ms ping length = 30 seconds.
3.5 RDT mode.
Same as ODT

Block 4 - Contact Phase

4.1 CZ Mode

Task#	Time (seconds)	Remarks
4.1.1	5	
4.1.2	26	1 ping
4.1.3	2	
4.1.4	26	1 ping
4.1.5	26	1 ping
4.1.6	2	
4.1.7	12	
4.1.8	26	1 ping
4.1.9	2	
4.1.10	-	3 pings (Monitor only)
4.1.11	78	1 cycle
4.1.12	2	
4.1.13	2	
	3 min 29 seconds	

4.2 BB Mode

4.2.1	5	
4.2.2	29	1 ping
4.2.3	2	
4.2.4	29	1 ping
4.2.5	29	1 ping
4.2.6	2	
4.2.7	12	
4.2.8	29	1 ping
4.2.9	2	
4.2.10	-	(Monitor only)
4.2.11	87	3 pings
4.2.12	2	
4.2.13	2	
	3 min 50 seconds	

4.3 Not used.

4.4 ODT Mode

4.4.1	10	
4.4.2	6	1 ping - range 5000 yds
4.4.3	6	
4.4.4	-	
4.4.5	2	
4.4.6	12	
4.4.7	18	
4.4.8	6	
4.4.9	6	
4.4.10	10	

4.4 ODT Mode (Continued)

Task#	Time (seconds)	Remarks
4.4.11	5	
	1 min 21 seconds	

4.5 RDT Mode

Task#	Time (seconds)	Remarks
4.5.1	10	
4.5.2	12	
4.5.3	6	
4.5.4	-	
4.5.5	2	
4.5.6	12	
4.5.7	18	3 pings
4.5.8	6	
4.5.9	6	
4.5.10	10	
4.5.11	5	
	1 min 27 seconds	

4.6 DIMUS

Task#	Time (seconds)	Remarks
4.6.1	10	
4.6.2	5	
4.6.3	5	
4.6.4	5	
4.6.5	-	(Monitor only)
	25 seconds	

Block 5 - Track Target

5.1 CZ Mode

Task#	Time (seconds)	Remarks
5.1.1	1	
5.1.2	26	1 ping (range over 50,000 yds)
5.1.3	5	
5.1.4	-	(Monitor only)
5.1.5	78	3 pings (1 cycle)
	1 min 50 seconds	(4 positions to CIC minimum)

5.2 BB Mode

Task#	Time (seconds)	Remarks
5.2.1	1	
5.2.2	29	
5.2.3	-	(Monitor only)
5.2.4	-	(Monitor only)
5.2.5	87	
5.2.6	1	
5.2.7	29	
5.2.8	29	
	2 min 56 seconds	

5.3 BBT Mode - Not used.

5.4 ODT Mode

Task#	Time (seconds)	Remarks
5.4.1	1	
5.4.2	-	(Monitor only)
5.4.3	6	1 ping
5.4.4	6	1 ping
5.4.5	6	1 ping
5.4.6	6	1 ping
5.4.7	-	(Monitor only)
5.4.8	-	(Monitor only)
5.4.9	-	(Monitor only)
5.4.10	18	3 pings
5.4.11	1	
5.4.12	12	2 pings
	56 seconds	

5.5 RDT Mode

5.5.1	1	
5.5.2	6	
5.5.3	1	
5.5.4	6	
5.5.5	6	
5.5.6	6	
5.5.7	-	(Monitor only)
5.5.8	-	(Monitor only)
5.5.9	-	(Monitor only)
5.5.10	18	
5.5.11	1	
5.5.12	12	
	57 seconds	

Block 6 - Conduct Attack

6.1 CZ Mode - Not applicable

6.2 BB Mode - Not applicable

6.3 BBT Mode - Not applicable

6.4 ODT Mode

Task #	Time (Seconds)	Remarks
6.4.1	6	1 ping
6.4.2	-	(Monitor only)
6.4.3	2	
6.4.4	120	For ASROC launch, time for torpedo to start

6.4 ODT Mode (Continuted)

Task#	Time (seconds)	Remarks
6.4.5	15	
6.4.6	60	
	3 min 23 seconds	(minimum for hit)
6.4.7	5	
6.4.8	5	
6.4.9	12	
6.4.10	6	
6.4.11	12	
6.4.12	2	
6.4.13	318	Wait for torpedo #1 to expend fuel
	6 min	6 minutes minimum time for 2nd shot
6.4.14	-	(Monitor only)
6.4.15	-	(Monitor only)
6.4.16	-	(Monitor only)
6.4.17	-	(Monitor only)

6.5 RDT Mode - Same as ODT 6.4

Block 7 - Conduct Lost Target Search

Times are entirely dependent on sonar conditions and target maneuvers. Following limits are presentations of excellent conditions:

7.1 CZ Mode

Task #	Time (seconds)	Remarks
7.1.1	5	
7.1.2	156	Doctrine search on 60° sector
7.1.3	-	(Monitor only)
7.1.4	5	
	2 min 46 seconds	(Minimum Regain Contact Time)
7.1.5	5	
7.1.6	15	
7.1.7	78	3 pings - one cycle minimum
	1 min 38 seconds	To Sonar Contact time
7.1.8	-	(Monitor only)

7.2 BB Mode

Task #	Time (seconds)	Remarks
7.2.1	5	
7.2.2	175	Doctrine search on 60° sector
7.2.3	-	(Monitor only)
7.2.4	5	
	3 min 4 seconds	To Regain Contact

7.2 BB Mode (Continued)

Task#	Time (seconds)	Remarks
7.3.5	5	
7.2.6	15	
7.2.7	87	3 pings
	107 seconds	To Sonar Contact
7.2.8	-	(Monitor only)

7.3 BBT Mode - Not applicable

7.4 ODT Mode

Task#	Time (seconds)	Remarks
7.4.1	5	
7.4.2	36	6 seconds per ping - doctrine search at 10° intervals over 60° sector
7.4.3	-	(Monitor only)
7.4.4	6	
	47 seconds	To Regain Contact
7.4.5	6	
7.4.6	5	
7.4.7	15	
7.4.8	18	3 pings
	44 seconds	To Sonar Contact
7.4.9	-	(Monitor only)

7.5 RDT Mode - Same as ODT

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APPENDIX F

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

FUNCTIONAL ANALYSIS OF TASK DETAILS

Prepared for:

U.S. NAVAL TRAINING DEVICE CENTER

Orlando, Florida

Prepared by:

HONEYWELL INC.
1200 East San Bernardino Road
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Note: For explanation of this Appendix see Section III of text.

APPENDIX F

FUNCTIONAL ANALYSIS OF TASK DETAILS

(Refer to Section III for explanation of codes and abbreviations used in this table.)

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
1.0	S	Decision	V	2	1	1	-	-	Once per watch
1.1	S	Procedure	F	1	1	1	-	-	(1.1 to 1.9 may be performed by
1.2	S	Procedure	F	1	1	1	-	-	any operator and checked by
1.3	S	Procedure	F	1	1	2	-	-	supervisor)
1.4	S	Procedure	F	1	1	2	-	-	Collect data from ships instruments
1.5	S	Procedure	F	1	1	1	-	-	
1.6	S	Decision	V	1	1	2	-	-	By formula
1.7	S	Decision	V	1	1	2	-	-	Easy decision based on data
1.8	S	Procedure	V	1	1	2	-	-	Follows 1.7
1.9	S	Decision	V	1	1	2	-	-	Based on theory
2.1									
2.1.1	A	Procedure	F	1	1	1	-	-	
2.1.2	All	Procedure	F	1	1	1	-	-	
2.1.3	S	Procedure	F	1	1	1	-	-	
2.1.4	S	Procedure	F	1	1	1	-	-	
2.2.1	All	Procedure	F	1	3	2	1	D	Maintenance of equipment extremely important
2.2.2	All	Procedure	F	1	3	1	-	-	Standard procedures

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Syn.	Remarks
2.2.3	All	Procedure	V	2	2	3	-	D	Recognize malfunctions and probable cause
2.2.4	S	Decision	V	2	1	3	1	D	Know and recommend alternate action
2.3.1	A	Procedure	F	1	1	2	-	-	Follow check list and make settings computed in Block I
2.3.2	B	Procedure	F	1	1	2	-	-	
2.3.3	T	Procedure	F	1	1	2	-	-	
2.3.4	S	Procedure	F	1	1	2	-	-	
2.3.5	All	Procedure	F	1	3	1	-	-	
2.3.6	A	Procedure	F	1	1	1	-	-	
2.4.1	S	Procedure	V	1	1	1	-	-	
2.4.2	S	Procedure	V	1	1	1	-	-	
2.4.3	S	Procedure	V	1	1	1	-	-	
2.4.4	S	Procedure	F	1	1	1	-	-	
2.5.1	B	Decision	V	2	1	3	2	D	Complete check-out of actual operating conditions. Comprehensive knowledge of system, ocean and interference causes and conditions is required
2.5.2	A	Decision	V	2	1	3	2	D	
2.5.3	T	Decision	V	2	3	2	1	D	
2.5.4	S	Decision	V	1	1	2	-	D	
. .									
2.6.1	S	Procedure	F	1	1	1	-	-	
2.6.2	S	Communication	F	1	3	2	-	-	May require explanations
3.1		CZ MODE							

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
3.1.0	A	Procedure	F	1	1	1	-	-	
3.1.1	A	Procedure	V	1	1	2	-	-	Same as 2.3.1
3.1.2	A	Procedure	V	1	1	1	-	-	
3.1.3	A	Monitoring	V	2	1	3	2	D	Skill and experience essential for effective performance
3.1.4	A	Monitoring	V	2	1	3	2	D	
3.1.5	S	Monitoring	V	2	2	3	2	D	
3.2		BB MODE							
3.2.0	A	Procedure	F	1	1	1	-	-	
3.2.1	A	Procedure	V	1	1	2	-	-	Same as 2.3.1
3.2.2	A	Procedure	V	1	1	1	-	-	
3.2.3	A	Monitoring	V	2	1	3	2	D	Skill and experience is essential for effective performance due to adverse signal/noise conditions
3.2.4	A	Monitoring	V	2	1	3	2	D	
3.2.5	S	Monitoring	V	2	2	3	2	D	
3.3		BBT MODE (Not used)							
3.4		ODT MODE							
3.4.0	B	Procedure	F	1	1	1	-	-	
3.4.1	B	Procedure	V	1	1	2	-	-	Same as 2.3.2
3.4.2	B	Monitoring	V	2	1	3	2	D	Very difficult due to multiple displays and low signal/noise ratios
3.4.3	B	Monitoring	V	2	1	3	2	D	
3.4.4	S	Monitoring	V	2	2	3	2	D	
3.5		RDT MODE							
3.5.0	B	Procedure	F	1	1	1	-	-	
3.5.1	B	Procedure	V	1	1	2	-	-	Same as 2.3.2

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
3.5.2	B	Procedure	V	1	1	2	-	-	
3.5.3	B	Monitoring	V	2	1	3	2	D	Very difficult due to multiple displays and low signal/noise ratios
3.5.4	B	Monitoring	V	2	2	3	2	D	
3.5.5	S	Monitoring	V	2	2	3	2	D	
3.6		DIMUS MODE							
3.6.0	S	Procedure	F	1	1	1	-	-	
3.6.1	S	Monitoring	V	1	1	2	-	-	
4.1		CZ MODE							
4.1.1	A	Communication	F	1	3	1	-	-	
4.1.2	A	Perceptual Motor	V	2	1	2	-	D	Cursor positioning accuracy is important
4.1.3	S	Communication	V	1	2	1	-	-	
4.1.4	A	Monitoring	V	2	1	2	-	D	Difficult due to masking effect of noise
4.1.5	T	Monitoring	V	2	1	2	-	D	
4.1.6	T	Procedure	F	1	1	1	-	D	
4.1.7	T	Monitoring	V	1	1	2	-	D	
4.1.8	T	Perceptual Motor	V	2	1	3	1	D	Difficult due to masking effect of noise accuracy required
4.1.9	T	Decision	V	1	1	2	-	D	
4.1.10	A	Monitoring	V	2	1	3	1	D	Critical when two targets are in area

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
4.1.11	S	Communication	V	1	3	2	-	D	
4.1.12	S	Decision	V	2	2	3	1	D	Depends on search doctrine and frequency of alert conditions
4.1.13	A	Procedure	F	1	1	1	-	-	
4.2		BB MODE							
4.2.1	S	Communication	F	1	3	1	-	-	
4.2.2	A	Perceptual Motor	V	1	1	2	-	D	Accuracy is important
4.2.3	S	Communication	V	1	1	1	-	-	
4.2.4	A	Monitoring	V	2	1	2	-	D	
4.2.5	T	Procedure	F	1	1	2	-	D	
4.2.6	T	Monitoring	V	2	1	2	-	D	
4.2.7	T	Perceptual Motor	V	1	1	2	-	D	
4.2.8	T	Perceptual Motor	V	2	1	3	1	D	Noise may be severe
4.2.9	T	Decision	V	1	1	2	-	D	Variability of data may cause some difficulty
4.2.10	A	Monitoring	V	2	1	3	1	D	Important for 2 target detection
4.2.11	S	Monitoring	V	1	3	2	-	D	Same
4.2.12	S	Decision	V	2	2	3	1	D	Based on doctrine and frequency of alert calls

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
4.2.13	A	Procedure	F	1	1	1	-	-	
4.3		(Omit)							
4.4		ODT MODE							
4.4.1	S	Communi- cation	V	1	3	2	-	-	
4.4.2	B	Percep- tual Motor	V	2	1	3	1	D	Must observe displays to pos tion cursor accurately. Accuracy is important
4.4.3	B	Monitoring	V	1	1	2	-	D	
4.4.4	A	Monitoring	V	1	1	2	-	D	
4.4.5	T	Procedure	F	1	1	1	-	-	
4.4.6	T	Percep- tual Motor	V	2	1	2	-	D	
4.4.7	S-B	Monitoring	V	2	2	3	2	D	Interpretation necessary to classify echo
4.4.8	B	Decision	V	2	1	3	2	D	Can enhance reception
4.4.9	S	Monitoring	V	2	1	3	2	D	Difficult to int grate all infor mation
4.4.10	ABT	Communi- cation	V	2	3	2	-	-	
4.4.11	S	Decision	V	2	1	3	2	D	Limited [illegible]for tion fo[illegible] cisi
4.5		RDT MODE							
4.5.1	S	Communi cation	V	1	3	2	-	-	

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
4.2.13	A	Procedure	F	1	1	1	-	-	
4.3		(Omit)							
4.4		ODT MODE							
4.4.1	S	Communi- cation	V	1	3	2	-	-	
4.4.2	B	Percep- tual Motor	V	2	1	3	1	D	Must observe 2 displays to posi- tion cursor accurately. Accuracy is important
4.4.3	B	Monitoring	V	1	1	2	-	D	
4.4.4	A	Monitoring	V	1	1	2	-	D	
4.4.5	T	Procedure	F	1	1	1	-	-	
4.4.6	T	Percep- tual Motor	V	2	1	2	-	D	
4.4.7	S-B	Monitoring	V	2	2	3	2	D	Interpretation necessary to classify echo
4.4.8	B	Decision	V	2	1	3	2	D	Can enhance reception
4.4.9	S	Monitoring	V	2	1	3	2	D	Difficult to inte- grate all infor- mation
4.4.10	ABT	Communi- cation	V	2	3	2	-	-	
4.4.11	S	Decision	V	2	1	3	2	D	Limited informa- tion for decision
4.5		RDT MODE							
4.5.1	S	Communi cation	V	1	3	2	-	-	

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
4.5.2	B	Procedure	F	1	1	1	-	-	
4.5.3	B	Perceptual Motor	F	2	1	3	1	D	Multi display coordination is required
4.5.4	A	Monitoring	V	1	1	2	-	D	
4.5.5	T	Procedure	F	1	1	1	-	-	
4.5.6	T	Perceptual Motor	V	1	1	2	-	D	
4.5.7	S-B	Monitoring	V	2	2	3	2	D	Difficult to integrate all information
4.5.8	B	Decision	V	2	1	3	2	D	Can enhance detection and get better information
4.5.9	All	(Repeat above)							
4.5.10	BT	Communication	V	2	3	2	-	D	
4.5.11	S	Decision	V	2	1	3	2	D	Difficult due to limited data for decision
4.6	Not included in analysis								
5.1		CZ MODE							
5.1A.0	A	Procedure	F	2	1	1	-	-	
5.1A.1	T	Procedure	F	1	1	1	-	-	
5.1A.2	T	Perceptual Motor	V	2	1	2	-	D	
5.1A.3	T	Communication	F	2	2	2	-	-	
5.1A.4	A-B	Monitoring	V	2	1	3	2	D	Essential to detect multiple targets

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff	Syn.	Remarks
5.1A.5	S	Decision	V	1	3	2	-	-	
5.1B.0	A	Procedure	F	2	1	1	-	-	
5.1B.1	T	Procedure	F	1	1	1	-	-	
5.1B.2	T	Perceptual Motor	V	2	1	2	-	D	
5.1B.3	O	Procedure	F	2	1	2	-	-	
5.1B.4	O	Procedure	F	2	1	2	-	-	
5.1B.5	A-B	Monitoring	V	2	1	3	2	D	To detect multiple targets
5.1B.6	S	Decision	V	1	3	2	-	-	
5.2		BB MODE							
5.2.0	A	Procedure	F	2	1	1	-	-	
5.2.1	T	Procedure	F	2	1	1	-	-	
5.2.2	T	Perceptual Motor	V	2	1	2	-	D	
5.2.3	A	Monitoring	V	2	1	3	2	D	To detect multiple targets
5.2.4	O	Procedure	F	1	1	1	-	-	
5.2.5	S	Decision	V	1	3	2	1	D	
5.2.6	A	Procedure	F	1	1	1	-	-	
5.2.7	T	Perceptual Motor	V	2	1	2	-	D	
5.2.8	S	Decision	V	2	3	2	-	D	
5.3		(Omit)							

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Syn.	Remarks
5.4		ODT MODE							
5.4.1	S	Communication	F	2	2	1	-	-	
5.4.2	B	Communication	F	2	2	2	-	-	
5.4.3	B	Perceptual Motor	V	2	2	2	-	D	
5.4.4	T	Monitoring	V	2	2	2	-	D	
5.4.5	T	Perceptual Motor	V	2	1	2	-	D	Accuracy is extremely important
5.4.6	T	Perceptual Motor	V	2	1	2	-	D	
5.4.7	B	Monitoring	V	2	1	3	2	D	To detect multiple targets
5.4.8	O	Procedure	V	2	1	3	2	D	Difficult due to variability of data
5.4.9	B	Monitoring	F	1	1	1	-	-	
5.4.10	S	Decision	V	1	1	2	1	D	
5.4.11	B	Monitoring	V	2	1	3	2	D	To detect multiple targets
5.4.12	T	Perceptual Motor	V	2	2	3	1	D	Accuracy is extremely important
5.5		RDT MODE							
5.5.1	S	Communication	F	2	2	1	-	-	
5.5.2	B	Perceptual Motor	V	2	2	2	-	D	
5.5.3	T	Procedure	F	2	1	1	-	D	

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
5.5.4	T	Communication	F	2	3	1	-	-	
5.5.5	T	Perceptual Motor	V	2	1	2	-	D	Accuracy is extremely important
5.5.6	T	Perceptual Motor	V	2	1	2	-	D	
5.5.7	B	Monitoring	V	2	1	3	2	D	To detect multiple targets
5.5.8	O	Procedure	V	2	1	3	2	D	Difficult due to variability of data
5.5.9	B	Monitoring	F	1	1	1	-	-	
5.5.10	S	Decision	V	1	3	2	1	D	
5.5.11	B	Procedure	F	1	1	1	-	-	
5.5.12	T	Perceptual Motor	V	2	2	3	1	D	Accuracy is extremely important
6.1		CZ MODE (Not applicable)							
6.2		BB MODE (Not applicable)							
6.3		BBT MODE (Not applicable)							
6.4		ODT MODE							
6.4.1	T	Perceptual Motor	V	2	2	2	-	D	Accuracy is essential
6.4.2	A-B	Monitoring	V	2	1	3	2	D	To detect multiple targets
6.4.3	B	Procedure	F	1	1	1	-	-	
6.4.4	B	Monitoring	V	2	1	2	-	D	

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
6.4.5	B	Communi-cation	V	2	2	2	-	D	
6.4.6	B	Communi-cation	V	2	2	2	-	D	
6.4.7	B	Communi-cation	V	2	2	2	-	D	
6.4.8	B	Procedure	F	2	2	2	-	-	
6.4.9	B	Procedure	F	2	1	2	-	D	
6.4.10	T	Perceptual Motor	V	2	1	2	-	D	
6.4.11	O	Procedure	V	2	1	2	-	D	
6.4.12	B	Procedure	F	2	1	2	-	-	
6.4.13	S	Decision	V	2	1	2	-	-	
6.4.14	A-B	Communi-cation	V	2	3	2	-	D	
6.4.15	O	Decision	V	2	3	3	2	D	Tactics and threat are in-volved
6.4.16	A-B	Communi-cation	V	2	3	2	-	D	
6.4.17	S	Decision	V	2	1	2	-	-	
6.5		RDT MODE	(Same as 6.4 ODT MODE)						
7.1		CZ MODE							
7.1.1	S	Communi-cation	V	2	3	2	-	-	
7.1.2	A	Monitoring	V	2	1	3	2	D	May be very difficult due to noise and sub-marine maneuvers

Code	Opr.	Type of Activity	Seq.	Crit.	Coor.	S.B.	Diff.	Dyn.	Remarks
7.1.3	T	Monitoring	V	2	2	3	1	D	
7.1.4	S	Communi-cation	V	2	3	2	-	-	
7.1.5	S	Communi-cation	V	2	3	2	-	-	
7.1.6	O	Communi-cation	V	2	2	2	-	-	
7.1.7	S	Communi-cation	V	2	3	2	-	-	
7.1.8	S	Decision	V	2	3	2	-	-	
7.2		BB MODE	(Same as 7.1 CZ MODE)						
7.3		BBT MODE	(Not used)						
7.4		ODT MODE							
7.4.1	S	Communi-cation	V	2	3	2	-	-	
7.4.2	B	Monitoring	V	2	1	3	2	D	Very difficult due to noise and sub-marine maneuvers
7.4.3	T	Monitoring	V	2	1	3	1	D	
7.4.4	S	Communi-cation	V	2	3	2	-	-	
7.4.5	B	Decision	V	2	1	3	2	D	Difficult due to pressure and uncertainty
7.4.6	S	Communi-cation	V	2	3	2	-	-	
7.4.7	O	Communi-cation	V	2	2	2	-	-	
7.4.8	S	Communi-cation	V	2	3	2	-	-	
7.4.9	S	Decision	V	2	1	3	1	-	
7.5		RDT MODE (Same as 7.4 ODT MODE)							

APPENDIX G

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

BIBLIOGRAPHY

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APPENDIX H

to

HUMAN FACTORS REPORT

for the

SQS-26 SONAR SYNTHESIS STUDY

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